UNITED STATES DEPARTMENT OF AGRICULTURE

REPORT ON THE AGRICULTURAL EXPERIMENT STATIONS, 1941

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REPORT ON THE AGRICULTURAL EXPERIMENT STATIONS, 1941

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INTRODUCTION

The year under review was a period in which the research work of the agricultural experiment stations proceeded for the most part along well-established lines, but with increasing emphasis upon those phases of immediate applicability to the national defense. Nearly 8,400 projects were under way, of which 3,235 were supported in whole or in part by Federal funds. From these resulted many new contributions to the improvement of agriculture and rural life and the enhancement of the national welfare. The work as a whole is summarized on pages 5 to 111 of this report.

The financial support for the extensive program under way was derived from Federal, State, and supplementary sources, reaching an aggregate of $22,433,550.29. This was an increase of $1,216,801.68 over the previous year, and was the high-water mark in the stations' history. The Federal-grant appropriations, authorized by the Hatch, Adams, Purnell, title I of the Bankhead-Jones Act of June 29, 1935, and supplementary acts, aggregated $6,862,500, an increase of $11,750, while the receipts from non-Federal sources rose from $14,367,998.61 to $15,571,050.29.

[1] This report, prepared with the extensive collaboration of the contributors enumerated on the opposite page and the assistance of other members of the Office staff, is submitted in accordance with a requirement carried for many years in the acts making appropriations for the support of the Federal Department of Agriculture for a report to Congress on the work and expenditures of the State agricultural experiment stations established under the Hatch Act of 1887 and supplementary legislation. The period covered is the fiscal year ended June 30, 1941.

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In addition to these direct sources of support the research work of the stations was aided and augmented by much cooperative effort. Extensive cooperation with the Department of Agriculture contributed to the progress of much of the station work and in like measure and manner the work of the stations contributed to the progress of Department studies. There was also much interstation cooperation, some of it informal and difficult of computation but which in the aggregate added considerably to the effectiveness of these research agencies.

THE COORDINATION OF RESEARCH

In addition to a large amount of informal cooperation, nearly 1,350 new or revised formal memoranda of understanding covering cooperative research between bureaus of the Department and the State stations were recorded, involving nearly 1,200 major research undertakings. All of the State stations, as well as all of the research bureaus and two of the action agencies of the Department, participated in this broad program, which involved from 8 to 55 research agreements per station and covered practical field problems of nearly every major aspect of farm production and rural life.

The amount of cooperative research brought to successful completion during the year was again relatively large. In all, more than 200 major cooperative studies were completed.

Interest in the defense activities of the Nation led to the focusing of research on the practical aspects developed out of broad studies begun in earlier years as recovery measures. The cooperative agricultural-adjustment study, which previously had been active on a national basis, was completed in all but six States and was being superseded in all but three States by the cooperative agricultural land use study for which it had laid much of the foundation. The results of numerous other cooperative studies were being used as a part of the procedure in agricultural planning.

Interstate coordination of agricultural research developed more rapidly than usual during the year. For example, the need to expedite movement of agricultural commodities from farm to market and from market to consumer developed into a problem of common concern to the majority of States. Informal community interest in marketing by regions resulted during the year in the formulation of comprehensive formal cooperative studies of marketing of livestock and livestock products in two major regions.

The increasing recognition by Federal and State agencies of the importance of good nutrition to health and welfare, particularly in times of national emergency, has added impetus to the efforts of groups of States to solve some of the practical aspects of certain basic problems of human nutrition. Among the studies continued by these groups were those dealing with the nutritional status of college women, the ascorbic acid metabolism of college students, and the variation in the components and nutritive value of vegetables grown in the South.

EXPERIMENT STATION PROJECTS

In 1941, the Federal-grant research of the experiment stations was conducted under 3,235 separate projects, 515 being supported wholly

or in part by Adams funds, 1,690 by Purnell funds, and 1,030 by Bankhead-Jones funds. Of the active projects, 600, or more than 18 percent, were revised or closed within the year. There were 374 new projects, 193 revisions, and 407 completions.

Information made available to the Office by the stations on their non-Federal research showed a total of 5,137 projects active in 1941. During the year, therefore, the experiment stations had 8,372 projects under investigation.

The need for prompt solution of problems and for release of funds for work on other urgent matters has called for continuous effort in selection and planning so that assistance might be rendered in the minimum of time. Pending the clearer definition of national needs and goals for defense and post-war adjustments and the particular types of services that the stations might render, the effort in 1941 was somewhat general in character. Nevertheless, projects were appraised as to defense implications and post-war applications, and consideration was given to possible budgetary shifts to meet emergencies.

Their efforts to expedite solution of pressing problems and redirect research on critical aspects of an emergency character are reflected in part in the project statistics for the year. The 600 Federal-grant projects revised or completed in 1941 compare with 435 in 1940, 429 in 1939, 405 in 1938, 333 in 1937, and 438 in 1936. According to the total of projects active during the year, the percentages revised or completed by these years, in the same sequence, were 18.5, 13.7, 14.2, 14.2, 12.6, and 17.2 percent.

BANKHEAD-JONES REGIONAL LABORATORIES

All of the 9 research laboratories established under the Bankhead-Jones Act of 1935 have now virtually completed their equipment and organization. Operations in cooperation with from 12 to 25 experiment stations each were actively under way.

The vegetable-breeding laboratory at Charleston, S. C., again had as its objective the production of high-quality products at reasonable cost under the conditions prevailing in the 13 cooperating States of the southeastern region and the development of new varieties adapted for home-garden use in that area. The program of the pasture research laboratory at State College, Pa., was designed to discover, or produce by breeding, pasture plants that will recover quickly from defoliation and will have such other desirable characters as palatability, high nutritive value, and persistency. Seven of the twelve State experiment stations in the northeastern region have developed cooperative research projects that are supplementing the studies in progress at the laboratory. Breeding work with Kentucky bluegrass is being conducted at the West Virginia and Pennsylvania stations, with white clover at the New Jersey and West Virginia stations, with orchard grass at the Maryland station, and with bentgrass at the Rhode Island station. The chemical composition of pasture plants is being investigated at the New Hampshire station. Overliming injury is being studied at the Connecticut (Storrs) station. A study of the fungus disease snow mold is in progress at the Pennsylvania station.

The work of the soybean laboratory at Urbana, Ill., was again carried on with the participation of the Bureaus of Agricultural Chemistry and Engineering and Plant Industry of the Department and the experiment stations of the 12 North Central States. The program included studies of both the utilization of soybeans and their constituents, and agronomic work directed toward the improvement of the oil content of the seed. During the past growing season, approximately 150 lots of hybrid seed involving crosses between superior strains were distributed to the cooperating stations in Ohio, Indiana, Iowa, and Missouri for testing under the environmental conditions existing in those States.

The laboratory for swine improvement at Ames, Iowa, had as its immediate task the development of inbred lines of swine with the purpose of increasing the productiveness of sows, growth rate of pigs, economy of gains, increased physical vigor, and desired quality of carcass. In connection with this program, inbred lines are being maintained at the 13 cooperating stations. The breeding herds total approximately 760 sows and 100 boars. A total of 678 litters were farrowed in 1940.

The sheep-breeding program of the laboratory for sheep improvement through breeding, located at Dubois, Idaho, in cooperation with 12 stations, continued to center around the objectives of an improved mutton type, longer staple wool, and the open-face characteristics so important on the range. During the past year there were 36 inbred lines in the laboratory program.

The animal disease laboratory at Auburn, Ala., which operates in cooperation with the experiment stations of 13 Southern States, has continued to work with Johne's disease of cattle and gastrointestinal parasites, particularly coccidiosis. A survey test in 8 of these States disclosed the presence of reactors to the diagnostic agent johnin in the majority of herds tested.

At the laboratory for the improvement of poultry viability, at East Lansing, Mich., major emphasis has again centered around fowl paralysis. Thirteen of the twenty-five States stations in the region have developed cooperative research projects that are supplementing the studies in progress at the laboratory. The viability of chickens from laboratory stock is being determined under different environmental conditions at the North Dakota, New Hampshire, Ohio, Oklahoma, and Indiana stations. Breeding studies with reference to improving viability are in progress at the Illinois, Maryland, Massachusetts, and Pennsylvania stations. Investigations in pathology are being conducted at the Connecticut (Storrs), Iowa, Indiana, Michigan, and West Virginia stations. Nutrition and anatomical studies are also being conducted at the Michigan station.

The laboratory at Riverside, Calif., for the study of salinity of irrigation waters undertook, in cooperation with 13 States, studies of the basic principles of salt action in the soil and the effects of various salts and concentrations of salts on plant growth and development.

At the laboratory established at Ithaca, N. Y., in 1939 for the study of the relation of soils to plant, animal, and human nutrition, a program of 6 studies formally approved by the collaborating agencies, which include the Bureau of Plant Industry and other bureaus of

the Department, 12 northeastern experiment stations, and other research groups, was undertaken. One of these studies has to do with the role of cobalt. In this connection turnip greens grown by several stations associated with the southern cooperative vegetable project have been analyzed for cobalt in an effort to obtain a pattern of distribution of this element in the southeast.

SPECIAL RESEARCH FUND PROJECTS

In addition to the Bankhead-Jones fund work noted above, another provision of the act sets up a special research fund for studies by agencies of the Department. These projects are assigned for leadership to the subject-matter bureaus of the Department most directly concerned, but of the 50 projects listed during the year 27 were carried on in cooperation with other agencies, including 29 State experiment stations. Among these projects were the continued studies of input as related to output in farming; storage of corn, other grains, and grain sorghum on the farm; interregional competition in the production and sale of farm products; possibilities of long-range weather and crop forecasting, including the relation of weather to crop yields; research in the statistics of agriculture and the associated statistical theory; specific studies relating to the nutrition of animals and the nutritive value of feeds; nutritive requirements for growth, fur production, and reproduction of foxes and minks; genetic variability in rats used for nutritional research; effect of artificial control practices on natural enemies of insect pests; comparative genetics and cytology of polyploid series in *Triticum;* research on plants used by American Indians, which may be a basis for new agricultural enterprises; blue mold disease of tobacco and its control; and research into the flue-curing of tobacco and the mineral nutrition of the product.

THE FOUR REGIONAL RESEARCH LABORATORIES

The 4 regional laboratories for research on new and extended uses for surplus farm commodities, authorized and established under the provisions of section 202 of the Agricultural Adjustment Act of 1938 and its amendment in 1940, were in active operation. The research program dealt with 14 major farm commodities and 3 composite groups of farm products, and took into account active research in the Department and the State experiment stations. During the year there have been relationships with 9 bureaus of the Department and 50 stations as a part of the over-all agreement with the Bureau of Agricultural Chemistry and Engineering.

PROGRESS OF AGRICULTURAL AND RURAL-LIFE RESEARCH

The summary which follows of the experiment station research carried on in 1941 is based mainly on the publications issued during the year by the 50 State stations, the Alaska, Hawaii, and Puerto Rico stations, and the Federal Puerto Rico station. The printed record for these institutions has also been supplemented as source

material by special reports from their directors as to significant accomplishments of the year.

The publications of the stations in 1941 comprised nearly 50,000 pages. This summary, therefore, does not attempt to cover all of the research projects active during the year and is necessarily incomplete as to details of the experimental work accomplished and the results obtained. The aim has been to make selection within the several fields to depict the wide range of the subjects studied and the findings having greatest significance in the solution of current problems.

The general plan followed in the discussion is that of recent years, but the space available has been curtailed to less than 50 percent of that in the corresponding report for 1940. In view of this situation and in order to expedite the publication of findings where possible, special provision was made for the transfer of the sections dealing with agricultural engineering and home economics to other mediums of publication. What would have been the section on agricultural engineering has been printed in Agricultural Engineering (Vol. 23 (1942), No. 6, pp. 181–185). The work in home economics is being published as Miscellaneous Publication No. 503 of the Department.

PLANT PRODUCTION, PRODUCTS, DISEASES, AND INSECT PESTS

FIELD CROPS, PASTURES AND RANGES, AND WEED CONTROL

CONTENTS

During the year research at the State experiment stations with field crops and closely related lines responded to defense needs and emergency demands with refined cultural practices; more productive varieties and strains of fiber, cereal, forage, oilseed, root and sugar crops, and tobacco, variously characterized by resistance to insects, diseases, and cropping hazards, adaptation to environmental differences, and suitability for food, feed, or industrial uses; economical control of weeds by cultivation and chemicals; more effective ways to improve and conserve soil fertility by use of fertilizers, green manures, rotations, and other practices; proper methods of harvesting, handling, and storage of crops to secure and retain the desired qualities; and preferred systems of establishing, managing, and conserving meadows, pastures, and ranges.

COTTON

Cotton investigations dealt with problems of varieties, their improvement and distribution, cultural methods, fertilizer practices, harvesting, and fiber quality.

Breeding and varieties.—Breeding work, supplemented by fundamental genetic and cytological research, and often in cooperation with the Department (B.P.I.), brought forth new cottons with sought-for-characters. For example, among the promising strains developed by the Louisiana station, Dixie-Triumph 366 is very wilt-resistant, vigorous, and fairly productive. It has a good-sized boll and satisfactory staple and lint percentage, and has been multiplied for distribution.

Tangible benefits of the breeding programs and varietal recommendations of the stations were in evidence throughout the Cotton Belt. In 1928 about 75 percent of the cotton grown in Louisiana stapled less than 1 inch, while in 1939 around 85 percent was 1 inch or longer. As a result of the selections introduced by the Alabama station, in 1940 less than 1 percent of cotton in the State stapled below seven-eighths of an inch, 13 percent was twenty-nine thirty-seconds of an inch, and 86 percent fifteen-sixteenths of an inch or longer, compared with 45, 53, and 2 percent, respectively, in 1929.

Fertilizers.—By experimentation with cotton on different soils in hill sections, the Mississippi station showed that most soils of sandy texture may need nitrogen, phosphorus, and potassium for cotton production with maximum economy. Silt or clay soils varied widely in fertilizer needs, some responding best to the three nutrients and others to phosphorus and potassium or nitrogen and potassium. In tests by the North Carolina station, cooperating with the Department (B.A.C. and E. and B.P.I.), fertilizer in side placements, i. e., 2½ inches to the side and 2 inches below the seed level at planting, averaged 1,321 pounds of seed cotton per acre, mixed with soil 1,174 pounds, and in a band under the seed 1,111 pounds.

Yields of seed cotton and earliness of maturity increased as the reaction of Cecil sandy loam rose from pH 5 to pH 6.5 in South Carolina station tests. Since nearly 40 percent of the farm soils of the State have pH values of 5.5 or lower, profitable returns evidently would follow application of limestone enough to raise the pH to the optimum of pH 6.0–6.5. Any boron deficiency resulting from overliming fine sandy loams in the Coastal Plain could be corrected by adding 2 to 5 pounds of boron per acre.

Fiber quality and properties.—Properties of cotton fiber in relation to position on the seed were studied by the North Carolina station to provide basic information for cotton-improvement work and spinning processes. Fiber population was found densest at and near the chalazal area of the seed and thinner downward toward the apical end and outward toward the raphe. No two varieties are alike in fiber distribution.

During the period of fiber development, the North Carolina station reported from its studies in cooperation with the Department (B.P.I.), rainfall and temperature changes influence fiber strength through changes in orientation of cellulose. These may be related to changes in cell turgor.

CORN

The Nation-wide survey in 1941 by the Department (A.M.S.) revealed that 33,000,000 acres, or about 37 percent of the 87,000,000 acres of corn in the United States, were planted with hybrid seed. Corn

Belt farms grew about 30,781,000 acres of hybrid corn in 1941, or 62 percent of the total corn plantings in that region (12 States), a substantial increase over the 25,676,000 acres (51 percent) in 1940. The total corn acreage in the Corn Belt had dropped from 62,000,000 to 50,000,000 acres since 1936, but at the same time yields were increasing so that production had not dropped proportionately. Material advances were also noted in the Pacific Northwest and Northeastern States. The smallest advance was in the South where adapted hybrids had not been developed on a large scale.

Major factors in the continued extension of hybrid-corn growing were the comprehensive improvement and distribution programs in operation in most of the Corn Belt States and also in an increasing number of other States. Stations whose breeding programs have not advanced far enough to permit the release of their own hybrids have been comparing hybrids produced by other stations and commercial growers for the information of corn growers in their own States.

Noteworthy new high-yielding hybrids include Florida W1, a double-cross hybrid, white flinty dent, resistant to weevil damage, by the Florida station; eight new yellow Minhybrids ranging from 85 to 115 days in maturity, by the Minnesota station; New York (Cornell) hybrids 29–3, 29–5, and 34–53; hybrid pops, by the Kansas and Indiana stations; a double-cross hybrid showing improvement over early adapted varieties in yield, maturity, and plant type, by the North Dakota station; new strains more resistant to insects and diseases, by the Wisconsin station; New Jersey Hybrid 2, highly resistant to European corn borer, and Hybrid 4, tolerant to corn borer, both surpassing old varieties and midwest hybrids and superior in silage value, by the New Jersey station; and new hybrids yielding 10 to 40 percent more than open-pollinated varieties, by the Texas station.

Fertility needs of corn.—The Georgia station found that for corn, continuous or following a moderately fertilized crop, 100 to 150 pounds of superphosphate should be placed under the corn and a side dressing of 125 to 200 pounds of sodium nitrate or other inorganic nitrogen made when plants are about 2 feet high. Fertilizer under corn might not be profitable after well-fertilized crops, and the side dressing could be omitted when corn follows a winter legume.

The growth of vetch obtained by March 15, turned under for corn by the Alabama station, resulted in more corn per acre than 32 pounds of commercial nitrogen per acre, and vetch growth by April 5 and 15 produced more corn than 64 pounds of nitrogen. Corn after vetch cost 13 to 14 cents per bushel, and that after nitrate applications 28 to 48 cents. Vetch should attain a minimum of 3.5 tons of green weight per acre before being turned under for corn.

That the corn crop could use fairly efficiently the nitrogen supplied as cyanamide when plowed under with organic matter (various crop residues) was observed by the Indiana station. Substantial amounts of this nitrogen remained in the soil for succeeding crops in the rotation. The practice was profitable in general, although its efficiency and profits were greater on lighter colored soils.

Cultural practices.—Corn increased in total weight and bushels per acre directly with deeper plowing from 4 inches to the maximum

depth of 12 inches in South Dakota station experiments. It was the only crop in the 4-year rotation corn, winter wheat, oats, and legumes showing this trend in total weight. Grain yields from wheat and oats also increased as the plowing for corn was deeper.

When bedded and planted in the water furrow by the Georgia station, corn averaged 33.3 bushels, planted in open furrow on land turned flat 28, and planted on top of the bed 21.4 bushels. Close spacings returned larger yields than wider spacings. Interplanting with legumes reduced the yield of corn, although increasing tonnage of dry matter per acre. The value of growing winter legumes to increase corn yields and to insure against soil erosion was evident.

WHEAT

Improvement.—Superior varieties combining yield and other desirable agronomic characters with resistance to disease, insects, cold, and drought and with good milling and baking qualities were the goals of the stations and cooperating bureaus of the Department (B.P.I. and A.M.S.).

Carala, a productive early stiff-strawed wheat indicated for pastry purposes, originally designated Alabama Blue Stem 89 and resembling Purple-straw in several characters, was released by the North Carolina station late in 1940. Marflum, a new hard white spring wheat, developed by the Washington station and the Department (B.P.I.) from Marquis-Florence × Graecum, yields well and has high test weight. Turkey 926, developed by the Utah station as a pure-line selection from Turkey winter wheat, stands and yields better than Utah Kanred, and was distributed during the year. A selection from Utah Kanred × Sevier, high yielding with stiff straw and apparently well adapted as a fall wheat on irrigated land, was ready for distribution.

Purdue 6 and 7, two superior strains derived from Purkof × Fulhio by the Indiana station, gave highly satisfactory results in State-wide comparisons with standard varieties and were being increased for naming and release to certain farmers for further multiplication and distribution in 1941. They have been outstanding in yield, resistance to loose smut and mosaic, straw, suitability for combine-harvesting, test weight, and in pastry quality. Sanford, the new rust-resistant, high-yielding winter wheat developed by the Georgia station cooperating with the Department (B.P.I.) was released to farmers during the year. Hybrid strains developed by the Texas station have shown promise in the Panhandle in tests in cooperation with the Department (S.C.S.).

Hazards.—Winter wheat plants were found by the Indiana station to acquire and lose hardiness repeatedly, depending upon air temperatures during winter; and variations in level of hardiness were found from week to week, from season to season, and among varieties. Seedlings grown on high levels of soil fertility were succulent and showed greatest injury; those grown on low and medium levels differed little in cold resistance. Plants infested with hessian fly were more susceptible to freezing than noninfested plants.

Crown composition of winter wheat in sucrose and dry matter contents was found more closely related to cold resistance than was leaf

composition in Nebraska station studies. Survival seemed to depend entirely on ability of the crown to resist frost injury. Plants hardened adequately under either decreasing or increasing day lengths. Light intensity, however, was important, for any diminution of light resulted in lower efficiency of hardening.

Ceres has usually surpassed other wheat varieties at the North Dakota station in heat resistance, bound-water content, and ability to continue growth at low soil moisture levels. In general, plants allowed to harden by wilting before treatment have been more resistant to high temperatures and have had high bound-water contents, and plants 1 or 2 weeks old were more resistant than those 1 month old. Wheats receiving abundant water up to treatment appeared less resistant than plants grown in a relatively dry soil.

OATS

Improvement.—Products of the cooperative oats-breeding program in which stations cooperated with the Department (B.P.I.), released during the year, included Uton (from Markton × Swedish Select), having a large white kernel and resistant to both loose and covered smuts, by the Utah station; Lelina and Letoria, selected from Lee × Victoria, resistant to smut and crown rust, both winter varieties, by the North Carolina station; and Miomark oats, developed by the South Dakota station from a backcross of a selection of Iogold × Markton to Markton, an early maturing white variety highly resistant to local races of loose and covered smut and resistant to the most prevalent races of stem rust, but susceptible to leaf (crown) rust. Promising new strains were under further development, prior to release, by the Indiana, Kansas, Louisiana, Minnesota, Montana, New York (Cornell), Tennessee, Washington, and other stations. The Fulwin, Tennex, and Forkedeer (Tennessee 092) oats, released recently by the Tennessee station, and the Alber variety by the Louisiana station, all winter types, were being grown on increasing acreages in their respective States.

Bond oats, introduced by the Department (B.P.I.) and used extensively by the Minnesota station in crosses with common varieties, excelled in resistance to crown rust and smut, in plumpness of grain, and in ability to withstand lodging, and characteristics of certain of the hybrids indicated that Bond is desirable as a parent in such crosses.

Adaptations.—For the hill sections of its State, the Mississippi station finds Red Rustproof strains, including Terruf, New Nortex, Appler, Ferguson 922, and Hastings most dependable, and the Fulgrain strains, Victorgrain, and Fulghum among the best of the earlier oats. Fall-sown oats have outyielded spring oats.

BARLEY

Improvement.—Beecher, a productive smooth-awned, early barley, was released to growers by the Colorado station and is indicated for nonirrigated lands. Belford, a hooded selection derived from Beldi × Horsford by the Washington station, was being distributed to farmers. Davidson and Randolph, two awned barleys developed

by the North Carolina station in cooperation with the Department (B.P.I.) and released in 1938, continued to make good grain yields. Iredell, released in the fall of 1940 to be used primarily as a forage barley, has also been outstanding in yields. Davidson and Iredell were found resistant, although not entirely immune, to all races of smut used in inoculation tests. Compana, an early two-rowed, hulled, semismooth variety, selected from a composite cross of the Montana station and distributed in 1941, is reported to be resistant to drought and grasshoppers. A new rust-resistant giant beardless barley, a high yielder of forage in tests in the lower Rio Grande Valley, was distributed by the Texas station to growers for the production of winter forage and cereal leaf meal. A high vitamin product (Cerophyl) manufactured for human consumption from the leaves of this barley and other cereals has been supplied to the Allied Armies.

RICE

Varieties.—The stations in the rice-growing States of Arkansas, California, Louisiana, and Missouri have cooperated with the Department (B.P.I.) in appraising the merits of different rice varieties. In Arkansas, Louisiana, and Texas, the Caloro and Acadia short-grain; Zenith, Early Prolific, and Blue Rose medium-grain; and Edith, Fortuna or Arkansas Fortuna, Nira, and Rexoro long-grain varieties were the most productive of the three grain types for the different maturity groups. These varieties are well suited for growing in these States, except Rexoro which cannot be grown in Arkansas owing to late maturity. In California and Missouri, the Colusa, Caloro, and similar short-grain varieties and selections produced the highest average yields. The leading varieties in 1940, based on the total acreage sown, in order of importance were Blue Rose, Early Prolific, Rexoro, and Caloro. Each of these stations continued to cooperate with the Department (B.P.I.) in problems of rice production, including improvement, culture, irrigation, soil fertility, and disease control.

Fertilizers.—The Texas station, working on different soil types and in different localities, found that with certain exceptions application of a mixture of 100 pounds each of ammonium sulfate and superphosphate per acre in the drill with the seed at planting was, in general, the most satisfactory fertilizer practice for rice. That the greatest need of rice soils is the incorporation of more organic matter was observed by the Louisiana station. Applying 3 tons of rice straw per acre each year with commercial fertilizer has resulted in increases in yields of rice amounting to as much as 15 or 18 bushels per acre.

BUCKWHEAT

Buckwheat production in northeastern, central, and northwestern Pennsylvania was shown in comprehensive adaptation, varietal, and fertilizer studies on the crop by the Pennsylvania station to have a definite place in the cropping system in relation to climate and soil conditions, being limited largely to the less productive soil areas of the Dekalb and Volusia series. It is an important emergency crop under conditions where other grains do not thrive.

Tartary buckwheat, the New York State station observed, is especially well adapted for use as an orchard cover crop, soil renova-

tor, and weed destroyer. It is much hardier and less subject to frost and thrives much better on the poorest land than the ordinary buckwheats.

FLAX

New varieties.—Viking flax, a North Dakota station selection from B–Golden × Burbank Golden, has a medium-sized golden yellow seed, is rust- and wilt-resistant enough for land not too badly infected with flax wilt, and withstands spring frost better than Bison, Buda, or Linota. Viking is about 6 inches shorter than Bison, but under favorable conditions grows high enough for harvest with a binder and generally makes as good an acre yield, with oil of better quality, especially light in color, and rapid drying. Biwing (Bison × Redwing), a new seed-flax variety released to farmers by the Minnesota station, combines the large seed size and high oil percentage of Bison with the excellent drying quality of oil of Redwing. Rio flax, introduced by the Texas station in 1939 as a rust-resistant variety, was being grown on about 5,000 acres in south Texas. The Department (B.P.I.) cooperated in the flax-improvement work.

Adaptations and production practices.—In a 13-year study of problems of flax production, the North Dakota station and the Department (B.P.I.) found that in general flax grown under hot, dry conditions produces less oil and oil with a low iodine number, whereas under favorable environment the number is high. Factors unfavorable to production of high-quality oil generally have resulted in a meal high in protein.

Cropping practices for seed and fiber flax, published from cooperative experiments, 1937–40, by the Georgia station cooperating with the Tennessee Valley Authority and the Department (B.P.I.), were concerned with adaptations of the spring- and fall-sown crop, varieties, soils and fertilizer needs, and cultural and harvesting methods. Results with flax so far have been promising, yet the station declares that the crop is in the experimental stage in Georgia.

Features of the California station seed-flax program, in which the Department (B.P.I.) and other agencies participated, included the continuous improvement of the Punjab (C. I. 20) variety, appropriate planting dates, cultivated rows, determination of the best stage for harvest to eliminate waste and improve quality, and the successful planting and growing of flax and alfalfa together.

POTATOES

Improvement.—A number of the newer varieties of potatoes, released to growers in recent years mainly as products of the national potato improvement program of the stations cooperating with the Department (B.P.I.), were undergoing further tests and study. As an example, Sequoia, a new variety developed by the North Carolina station and the Department (B.P.I.), averaged over 5 years 347 bushels per acre as compared with Chippewa 263, Irish Cobbler 224, and Katahdin 218 bushels, and yields up to 600 bushels per acre have been recorded. Outyielding Rural by 100 to 150 bushels per acre and Dakota Red by 50 to 100 bushels in Maryland station tests, Sequoia was expected to replace Rural in Garrett County and Dakota Red elsewhere in Maryland. It also was high-yielding in nearly all

trials of the West Virginia station, and, because of insect resistance and inherent vigor was very promising for home and subsistence gardens.

Katahdin, Chippewa, and Sebago were shown to be resistant to mild mosaic in studies of adaptation and yield performance by the Washington station. They have been more uniformly smooth than Russet Burbank, with eyes shallower and further apart than on Triumph and Cobbler, which makes preparation for the table easier and less wasteful. Sebago, a late potato, was outstanding for high yields, smooth tubers, and disease resistance. Pontiac, which appeared to be an outstanding late red variety, resembles Sebago in vine growth. Among other promising developments, this station mentions two productive late Katahdin selfs—both free from veinbanding disease—No. 1892, a round variety, and No. 3708, a long type.

In harmony with the basic objectives of the national program, breeding work and concurrent genetic and physiological research in progress at the above-mentioned stations and at the Louisiana, Maine, Minnesota, Nebraska, New Jersey, New York (Cornell), North Dakota, and Wyoming stations were aiding in the perfection, prior to release, of a number of promising new potatoes, variously incorporating seasonal and regional adaptations, productiveness, resistance to viruses, scab, late blight, and other diseases, and to insects and drought, and superior market and table qualities.

Fertilizers and soil conditions as affecting yield and quality.—In experimenting with Bliss Triumph potatoes on the marl soils of Dade County, the Florida station determined that mixtures to be applied at rates of about 1,500 to 2,000 pounds per acre should not exceed 3 or 4 percent of nitrogen, 8 percent of phosphoric acid, and 4 or 5 percent of potassium. With ordinary 4–8–5 and 3–12–8 analyses, about 1,500 to 2,000 pounds were the best amounts and 1,500 pounds was usually most profitable. The organic nitrogen carriers milorganite, blood-and-bone tankage, and dried blood profitably outyielded other sources.

Soils of pH 4.8 to about pH 5.5 reaction, the New York (Cornell) station finds, usually have produced the highest yields, while on soils above pH 7.0 to 7.5 yields are always lowered. Yield of scabby tubers usually reaches a peak at about pH 6.5 and then declines at higher pH. Organic matter incorporated into the soil increased the yields of potatoes at all pH ranges.

The average specific gravity and degree of mealiness of potato tubers were observed by the same station to rise when a soil pH of 4.88 to 5.30 was increased to pH 6.73 to 7.19, and to fall slightly at pH 7.26 to 7.55. Least blackening of cooked potatoes occurred at the higher pH ranges. In general, specific gravity and dry-weight percentage of tubers fell as applications of 4–8–8 fertilizer rose from 1,000 to 3,000 pounds to the acre. These determinations were lower in irrigated tubers at each rate than in those not irrigated, which were the more mealy at the higher rates. Degree of blackening usually increased as the fertilizer rate was higher.

In studies by the Montana station under a wide range of conditions, phosphorus used alone was almost universally beneficial to Netted Gem and Bliss Triumph potatoes and was always included

in any good combination. Nitrogen used alone has been of very little value, resulting in lower grades and poorer maturity and netting, but its use with phosphorus is essential for maximum improvements. Potassium lowered maturity and netting, either alone or in combinations. Boron was deficient in certain areas of western Montana, but was significant only when applied with phosphorus or the nitrogen-phosphorus combination.

The fertilizer ratio has had a pronounced influence on the cooking quality (mealiness) of potatoes in New Hampshire station experiments, but could be varied to maintain both high quality and high yields. Fertilizers relatively high in potassium have lowered cooking quality, whereas extra phosphorus increased quality and yields slightly.

Seed, storage, and harvest.—In seeking conditions for best storage of table potatoes and seed stock and reasons for certain losses in storage, the New York (Cornell) station determined that tubers stored for 8 to 12 days at 63° to 68° F. lost less weight and decayed much less in subsequent storage than those held for the same time at 39° to 44°. When dug with a padded digger and picked up in padded containers, potatoes sustained far less shrinkage and decay losses than those handled in the usual manner. Plants from seed tubers held in cold storage until planting time appeared above ground in the order of storage temperatures 50°, 40°, 35°, and 32° F., and the largest number of stems per seed piece, of tubers per plant, and of U. S. No. 1 size tubers, and the higher final stands of plants were produced by seed stored at the higher temperatures.

Practical methods of waterproofing cellars and of maintaining good conditions for holding seed potatoes until June in western Nebraska were being developed and put into practice by the Nebraska station. That spring-grown Louisiana potatoes may be kept in satisfactory common storage over the summer for table purposes or local markets was demonstrated in further storage studies by the Louisiana station. The No. 2 whole potatoes gave better stands and higher yields than cut potatoes in fall planting. By storing fall potatoes at fairly high temperatures, sprouting evidently can be hastened and the spring crop from fall-grown seed will mature about the same time as the crop from certified seed. Seed tubers attaining full maturity on vines in the spring crop, harvested July 6, were found most desirable by the Oklahoma station because they sprouted faster in fall plantings than did immature seed, harvested June 15. Cold storage spring-grown seed was slower in sprouting and emergence and less desirable than seed from common storage.

Failure of potato vines to die down from natural causes at the desired time often leaves the grower with the alternative of digging the tubers before maturity or risking a loss due to leaving them in the ground too long. The Idaho station found that proper ripening of the tuber could be brought about at the desired time by sprays. Ammonium sulfate, 1 pound per gallon of water, applied at the acre rate of 200 gallons, resulted in slower death of vines than from kerosene spray, with slight reduction in tuber yield during 10 days after spraying. Tubers in this treatment were much riper than those from untreated vines, were much less easily scuffed, and had a higher average number of layers of periderm cells.

SWEETPOTATOES

Sweetpotatoes are well adapted to Mississippi among other Southern States, and their production for the starch industry, as aided by Mississippi station research in cooperation with the Department (B.P.I.), should contribute materially to the cash income of farmers. Results of bedding tests demonstrated that proper watering, fertilizer, and uniform heat, sandy loam, sand, and the use of old sawdust produced good plants. No variety was found that possessed good culinary qualities and at the same time produced starch enough to be desirable for commercial manufacture. Larger total yields resulted when plants were spaced closer than 12 to 15 inches, yet net profits were lower. According to fertilizer tests, in general 500 pounds of 6–8–4 fertilizer, combined with 12-inch spacing, gives the greatest net returns. Starch content was not affected by the fertilizers used.

With the fertilizer treatments recommended for the several areas of Mississippi and planting from May 15 to June 15, the Mississippi station found that plants of the Porto Rico, a table variety, should be spaced about 1 foot apart in rows 3 to 4 feet wide. Earlier plantings may be spaced wider if the grower can use oversize potatoes, while later plantings may be set as close as 8 inches. Close spacing of early plantings also resulted in higher total yields in experiments by the South Carolina station. Larger yields of No. 1 roots were produced by the Georgia station from plants spaced 12 and 16 inches apart than from closer or wider spacings, and plantings before May 1 produced higher yields of all grades than did later plantings. Spacings of 18 and 24 inches were very promising at the Louisiana station. The above studies were in cooperation with the Department (B.P.I.).

Electric heaters, the South Carolina station finds, maintain curing and storing temperatures uniformly throughout the sweetpotato storage house and aid greatly in curing. The curing process is facilitated greatly by maintenance of temperatures from 80° to 85° F. and relative humidities of 80 to 85 percent. For long storage, temperatures of 50° to 55°, with 80 to 85 percent relative humidities, are recognized as best. From 0.5 to 1 kilowatt-hour of electricity has sufficed to cure and from 1 to 2 kilowatt-hours to store 1 bushel of roots. Advantages of electricity as a source of heat for curing and storing sweetpotatoes have been reported by the Virginia station also.

Crosses between Nancy Hall and Porto Rico have given the highest percentage of desirable seedlings thus far in breeding work at the Louisiana station conducted in cooperation with the Department (B.P.I.). One of the best seedlings contained twice as much carotene as the best strain of Unit I Porto Rico.

TOBACCO

Production practices.—Profitable methods for flue-cured tobacco, derived from extensive experiments by the Virginia station, include the choice of well-drained soils with structure and texture providing good aeration and easy cultivation; rotations omitting legumes but supplying to the soil considerable organic matter from nonlegumes; and tall-growing varieties adapted to harvesting by the priming method, as Yellow Mammoth, White Stem Orinoco, Yellow Pryor, Virginia Bright, and Gold Dollar. Plant beds should be steam-

sterilized or burned, and fertilized with 1 to 3 pounds per square yard of a 4–8–3 or similar formula, plants set out from 20 to 24 inches apart in 4-foot rows and topped to leave from 14 to 20 leaves, and harvested by pulling leaves as they ripen rather than by cutting the plant.

Fertilizers.—On good tobacco soils under average conditions, the Virginia station reports that 1,000 pounds per acre of fertilizer analyzing nitrogen 3 percent, phosphoric acid 10, and potash 6 percent may give satisfactory results with flue-cured tobacco. On heavier soils, the rate may be lowered to 800 pounds per acre or the nitrogen percentage reduced.

The Connecticut (State) station observed that several nitrogen sources may safely be included in the cigar tobacco formula to provide the most uniform ratio of nitrates to ammonia and to furnish sufficient nitrates in the later growth period. The superiority of soybean meal over cottonseed meal and the beneficial residual effects of stable manure on yield and grading were also demonstrated.

Quality.—White Burley differs distinctly from other types of tobacco in market requirements and in response to production and curing methods. Kentucky station research demonstrated that with adequate moisture and mineral nutrients the yield of White Burley is proportional to available nitrogen, about 2,000 pounds of leaf per acre being harvested from very productive soils. Quality improves as the yield rises until 1,200 to 1,400 pounds per acre are reached, then remains the same above this, except that at very high yield levels it tends to decline somewhat, particularly with heavy applications of nitrogen.

Curing has always been a major problem of the tobacco grower, particularly with air-dried types where the process depends largely on outside weather conditions. The Kentucky station confirmed its previous determinations of optimum relative humidity (65 to 70 percent) and temperature ranges (60° to 90° F.) for curing burley tobacco.

SUGAR CROPS

Sugar beets.—Practices found successful in growing sugar beets under irrigation in the northern Great Plains region and published by the Department (B.P.I.) were based on experiments conducted chiefly in cooperation with experiment stations in Nebraska, South Dakota, and Wyoming, and, allowing for local differences in conditions, are also applicable to other areas growing the crop under irrigation. Effective sugar beet production practices, likewise based extensively on their research and experience, were also recommended by the Michigan and Minnesota stations.

Early planting (August 25 to September 1) with close spacing of sugar beet plants in the row, the Arizona station reports, has produced a higher percentage of seed stalks and higher seed yields than later plantings. Because of the adoption of this practice by growers, the 1941 crop was planted about 2 weeks earlier than usual. Highest seed yields were obtained by the New Mexico station cooperating with the Department (B.P.I.) after fallow and cantaloup following either alfalfa or cotton, and alfalfa land consistently outyielded cotton land. Manure was more beneficial after corn, Sudan grass, and barley than after cantaloup and fallow.

Rotations in which the sugar beet as the major crop was grown in various sequences by the Ohio station in cooperation with the Department (B.P.I.) showed that the arrangement giving the greatest total advantage for the rotation as a whole, although possibly soil-depleting, is soybean hay, corn, soybean seed, sugar beets, and oats.

Sugarcane.—When four sugarcane varieties were grown by the Hawaiian Sugar Planters station, in complete solutions and in solutions lacking nitrogen, phosphorus, potassium, calcium, magnesium, sulfur, iron, manganese, or boron, normal growth and cane and sugar yields of each were depressed when any one of these elements was omitted from the solution. Typical deficiency symptoms for each of the 9 elements developed on all canes, but some varieties showed a much higher degree of tolerance to certain deficiencies than others. Quality of juice of all canes was affected when certain elements were omitted. Varieties appeared to have different nutritional requirements.

One crop of summer legumes turned under, the Louisiana station reported, furnished as much plant food as was profitably usable by the plant-cane crop under the rather unfavorable conditions. Not more than 36 pounds of commercial nitrogen per acre could be used profitably by a cane crop.

SORGHUMS

New sorghums increased and distributed to farmers by the Texas station were Early hegari, a variety identical with, but 10 days earlier than, common hegari, and much surer of production in drier regions; and Sooner milo No. 8, a new selection resistant to *Pythium* root rot, which has a few more leaves and is expected to replace the old susceptible Sooner. Other products of this sorghum-breeding work were Sudan grass strains or varieties expected to be released for distribution in 1942. These are examples of genetics applied to plant breeding wherein a group of genetic characters, i. e., juicy stem, sweet stem, nonshattering seed habit, a distinctive glume marker, and resistance to red spot, have been transferred from Leoti sorgo to Sudan grass through crossing, backcrossing, and selection. These sweet, juicy strains are preferred by livestock and may replace the old type of Sudan grass. The distinctive glume color is important in connection with elimination of Johnson grass mixtures.

Use of sorghum stubble and seeding of late cover crops to protect serious wind-erosion areas, the growing of more sorghum-type crops in the mountain valleys, and the use of more corn and sorghum crops in the high plains wheat-growing sections of the area are results of major benefit derived from New Mexico station experiments in northeastern New Mexico.

Starches equal in purity to commercial starches have been prepared by the Kansas station from standard Blackhull kafir and Leoti Red and Early Sumac sorgos. Starch derived from Blackhull kafir was found to be a very low-viscosity type, which suggests that it might be superior in hydrolytic, fermentation, and other processes where low viscosity is desirable.

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SOYBEANS

The demands for soybeans and soybean products—oil, protein, and meal—for emergency or defense requirements provided additional outlets for the rapidly increasing crop.

Improvement.—Magnolia, a productive new yellow-seeded soybean suitable as a seed type for crushing and also yielding a fair amount of hay, developed by the Louisiana station, was released to farmers. Plans were to increase several yellow-seeded hybrids promising for the sugarcane section where high yields of forage are required. Gibson, a yellow-seeded variety bred by the Indiana station, was being multiplied and distributed. Several yellow-seeded varieties suited to the hay needs of Missouri farmers and seed requirements of processors were produced by the Missouri station. Seneca soybeans, released by the New York (Cornell) station in 1941, have usually matured in spite of weather unfavorable for seed production. The soybeans mentioned above were bred in cooperation with the Department (B.P.I.)

Varieties and production.—Soybeans for hay, silage, green feed, and pasture were being raised in quantity in New Hampshire, but few were being grown for seed. Seed production may not find favor under current economic conditions, the New Hampshire station observes, except perhaps on dairy farms where threshing equipment is available and the beans can be used as a concentrated feed. Leaders in forage production were the Dunfield, Mukden, Black Eyebrow, and Manchu, and the Harbinsoy varieties.

Early-maturing soybeans produced the highest yields in Texas station tests, but many late-maturing sorts appeared desirable for forage. At Weslaco, in the lower Rio Grande Valley, all strains when fall-planted matured rapidly and on about the same date with a maximum acre yield of 13.5 bushels of seed, whereas attempts to produce seed from spring plantings have failed. Hay tests by the New York (Cornell) station demonstrated that early and medium early soybeans produced more dry matter per unit area by August 25 than the later maturing kinds, which should permit of earlier hay making with little loss in yield.

Production practices.—The farmers' practice of growing mixtures of soybeans and Hungarian millet for hay resulted in yields from 24 to 62 percent higher than from the soybeans grown alone in New Hampshire station tests. Definite growth responses followed the addition of 1 to 2 tons per acre of lime on acid soils, and they were greater after magnesium limestone than after calcium limestone. Good forage yields could be produced with moderate application of manure and superphosphate or complete fertilizer.

Edible soybeans.—The introduction of edible types of soybeans suitable for use in the green or the dry stage and having table qualities superior to ordinary commercial types is expected to go far in overcoming earlier prejudices and to result in greater use of the soybean as a food in the United States. That production of vegetable-type soybeans was successful from Maine to the Pacific Coast and from near sea level to an altitude of 8,000 feet, the Illinois station reports from its cooperative study of range of adaptation of varieties. Early varieties, the best producers in most localities, were the only ones well adapted to northern regions.

ALFALFA

Varietal improvement.—Uniform alfalfa nurseries, in which the Department (B.P.I.) has cooperated with stations in most of the States and in two Canadian provinces represented in the Alfalfa Improvement Conference, in determining forage and seed yields, stand survival, incidence of diseases, and plant characters of standard varieties and new strains, have continued to be a major factor in alfalfa improvement. Advanced nurseries, a new type of uniform nurseries begun in 1941, include strains approved by the conference. The new wilt-resistant strain, A136, developed by the Nebraska station and the Department (B.P.I.) as a composite of five strains outstanding in resistance to bacterial wilt and cold and resembling the best commercial alfalfas in forage and seed production, was grown on 117 acres by nine cooperating stations, and 1,000 pounds of seed were produced. A selection of Kansas common, having a high degree of wilt resistance, was being increased for distribution by the Kansas station. Many other new lines were under intensive study at the Arizona, Kansas, Montana, Nebraska, New Jersey, New York (Cornell), South Dakota, Wisconsin, and other stations.

Alfalfa production.—The more recent information published by the Nebraska station on production practices and varietal adaptation of alfalfa was based largely on its extensive research in cooperation with the Department (B.P.I. and A.M.S.). Southern domestic and foreign alfalfas not cold resistant proved inferior in stand longevity and yield compared with Nebraska and Northern commons, Grimm, Baltic, Cossack, and Ladak, and with Hardistan, which is resistant to bacterial wilt. Cossack, Baltic, Hardigan, Kansas, Utah, and South Dakota commons, German, and Hungarian have equaled or surpassed Grimm in yield, while Orestan, Hardistan, Kaw, and Turkistan have been superior in stand longevity.

Seed production.—The Arizona station found that when the moisture content in the third to fifth foot of soil exceeded 20 percent during the first part of blooming, alfalfa made luxuriant vegetative growth but with low yield and poor quality of seed. The highest yield of good seed was made under medium irrigation with subsoil moisture of about 10 percent at the beginning of blooming.

The Nebraska station and the Department (B.P.I.), cooperating in seed-producing areas, found insects, especially the *Megachile*, *Nomia*, and *Bombus* species of bees, to be important factors in alfalfa-seed setting through tripping and cross-pollinating of flowers. Marked improvement in seed yield resulted from effective control of *Lygus* bugs in Utah station studies cooperative with the Department (B.P.I.).

CLOVERS AND OTHER LEGUMES

Clover.—Distinct differences between red clovers from different sources in ability to survive the second winter were observed by the New York (Cornell) station. Kentucky 101 and Cumberland have been the most valuable strains of red clover in New Jersey station tests, strains from the far West inferior and little better than European stocks, and strains from the Middle West inconsistent in performance. Extensive tests by the Pennsylvania station cooperating with the De-

partment (B.P.I.), which formed the basis for advice to farmers as to seed sources, showed Pennsylvania strains to average 8,526 pounds per acre for first and second cuttings, other domestic strains 8,143 pounds, and foreign strains 7,564 pounds.

Ladino clover, a large variety of white clover included since 1930 in Connecticut (Storrs) station experiments, proved to be one of the best legumes for hay and pasture in the region, producing from 2,500 to 5,500 pounds of dry matter per acre. It has been less subject to heaving and has yielded more when seeded with a grass than when sown alone. Orchard grass was most satisfactory in mixtures with Ladino for pasture and timothy with Ladino in mixtures for hay. Adding Ladino to red clover mixtures increased hay yields by about 1 ton per acre. Ladino has been more tolerant of acid-depleted soils than alfalfa and of soils too wet for red clover, and has given definite responses to potassium, lime, and superphosphate. Much less sensitive to severe cutting or grazing than alfalfa, it maintained better stands when not cut until 6 or 8 inches high and not closer than 4 inches.

Strawberry clover should be sown in early spring at the rate of 5 pounds per acre on land plowed and worked into a good seedbed; and mowed twice the first summer if necessary to check competing plants. The soil should be kept moist the entire first season, and pastured moderately. These suggestions came from experiments by the Colorado station in cooperation with the Department (B.P.I.).

To establish clover successfully, the Florida station reports that the soil must be fertilized properly and suitable varieties planted under adapted ecological conditions during a rainy period in October or November on closely grazed sods or well-packed seedbeds. Clover has thrived on acid soils, such as low-lying phases of fine sands and acid mucks, but slightly acid or alkaline soils with calcareous substrata, such as mucks and sandy mucks and low marl hammocks, also proved satisfactory. A mixture of Louisiana White Dutch and California bur-clover appeared to be the most promising combination.

Lespedeza.—Management practices for Korean lespedeza grown continuously were published by the Missouri station, which also gave directions for preparing seedbeds for spring or fall grains to be planted after lespedeza has matured seed. Korean lespedeza appeared to be adapted to all sections of its State, the Virginia station finds, while common, Tennessee No. 76, and Kobe were not well adapted for elevations above 1,500 feet. Annual lespedezas have done best when from 10 to 30 pounds of viable seed per acre were sown from 40 to 60 days before the last average date of killing frost, broadcast on small grains, pastures, or specially prepared fields, and covered lightly. Yields of all varieties were increased by fertilizers, and all, especially Korean, responded favorably to lime. Sericea (*Lespedeza cuneata*), the perennial, has produced heavy hay yields on relatively poor and acid soil without lime, and yields could be increased decidedly by fertilizing. Although sericea may be seeded on small grains in late winter or early spring, best results have followed planting scarified seed from March 15 to April 15 on specially prepared soil.

Observing that the most erosive rains fall in July and August, the Tennessee station found that lespedeza is an excellent crop for preventing soil erosion during this danger period. Alfalfa has been

superior to sericea for hay and for silage, but the latter is also a valuable crop under certain conditions.

Alyceclover.—Alyceclover (*Alysicarpus vaginalis*) in extensive Florida station experiments produced 0.5 ton of hay per acre on well-drained untreated Norfolk soil and 1.5 tons when receiving 500 pounds of lime, 200 pounds of superphosphate, and 50 pounds of potassium chloride per acre. Well-drained soils appeared essential. Without potassium, a leaf spot identified as potassium deficiency developed, which caused defoliation and retarded growth. Practical cultural directions have been published by the station and by the Department (B.P.I.).

Trefoil.—Birdsfoot trefoil in the first year produced less dry matter as hay than alfalfa or red clover, but outyielded them on poor hill lands, in New York (Cornell) station studies. For pasture, its yields compared favorably with wild white clover in the first harvest year, but somewhat less than Ladino clover. Early spring seedings were superior to late spring seedings, while fall seedings were unsuccessful. Analyses showed it to be about equivalent to other common legumes in feeding value in the hay and pasture growth stages.

Sweetclover.—Methods for growing sweetclover for soil improvement, for pasturage, for hay, and for reestablishing grass on abandoned eroded areas were published by the Indiana and Oklahoma stations.

In production tests by the Nebraska station in cooperation with the Department (B.P.I.), greater forage yields came from the first-year crop when harvested for hay rather than as pasture, and largest first-year yields were from the Iowa Late White, Evergreen, Spanish, and Madrid varieties.

Among the leading sweetclover varieties studied by the North Dakota station during several years, Albotrea and common yellow had the most stems per plant, were most leafy, and made the most successful stands, whereas common white led these in hay yields.

Winter legumes.—Increases of 500 to 600 pounds of seed cotton per acre were obtained by the Louisiana station after Austrian Winter peas, *Melilotus indica*, and hairy, common, and Hungarian vetches had been turned under. Furthermore, their residual effects were evident in gains of 240 to 300 pounds of seed cotton in the second year and about 200 pounds in the third year. The use of 3.5 to 4 tons of legume green manures per acre resulted in larger increases in cotton yield than did 36 pounds of nitrogen from sodium nitrate.

Winter legumes usually have thrived in the Yazoo-Mississippi Delta when sown in October in Mississippi station experiments. Subsequent yields of seed cotton and the nitrogen added to the soil showed that legumes gave best results when disked thoroughly and completely covered when bedded. Winter legumes cost about as much per acre as equivalent commercial nitrogen, and returned net profits of from 18 to 40 cents for each pound of seed planted. Fertilizing cotton following winter legumes usually was not profitable.

Maximum benefits of green manuring, the South Carolina station cooperating with the Department (B.P.I.) observed, are obtained by storing organic matter during the soil-improvement period and then releasing by decomposition the contained nutrients when of most benefit to the next crop. On porous soils, winter cover crops hold nutri-

ents released by decomposition of a summer green manure until used by a crop in the next season.

Peanuts.—The peanut-breeding program of the Georgia station, currently in cooperation with the Department (B.P.I.), has resulted in about 1,350 strains worthy of further trial, including the general types, disease-resistant bunch with nonsprouting seed, high-yielding strains similar to Spanish but not disease resistant, very tall, erect bunch types for hay, very viny bunch types for cattle feed, and high-yielding runner with low oil percentage and early-maturing runner, both for hogging-off. The station released a selected strain of Spanish to growers, and the North Carolina station released Virginia Bunch strain 8.

On most soils the Georgia station obtained best increases with Spanish peanuts from 400 pounds per acre of a 6–6–6 fertilizer applied before planting, as 300 pounds of a 3–8–8 plus a side application of 100 pounds of sodium nitrate, or as 150 pounds of superphosphate under the crop and side-dressing with 150 pounds of sodium nitrate and 50 pounds of potassium chloride. North Carolina runner peanuts seemed not to respond as well as Spanish to fertilizers, especially nitrogen. Best yields of peanuts seemed to have been obtained after cotton or tobacco.

Use of 400 pounds per acre of dolomitic limestone in the row at planting by the North Carolina station increased shelling percentages of peanuts and gave a fair profit oftener than applying gypsum on foliage at blooming. A 1-ton crop of peanuts with a 2-ton crop of hay removed mineral nutrients equivalent to 300 pounds of an 0–8–34 fertilizer, indicating the potassium-depleting nature of the crop. While potassium applied alone increased average yields and profits, it should be used with calcium to avoid lower shelling percentages. Calcium with potassium, e. g., dolomitic limestone in rows at planting followed by a side dressing of potassium chloride, gave higher and more profitable yields of good peanuts and replaced part of the potassium removed by the crop.

GRASSES AND HAY

New grasses.—Several introduced grasses have shown special promise as grazing crops, in studies by the Florida station cooperating with the Department (B.P.I.). Paraguay Bahia has produced nearly twice as much grazing as the common strain of Bahia and tends to be less susceptible to cold and disease. *Digitaria serotina* makes rapid growth, spreads well by stolons, and tends to produce a higher percentage of viable seed than other stoloniferous strains. Another species of *Digitaria*, also rapidly growing, is winter hardy, endures burning well, and is especially palatable. It produced 4,640 cow-hours of grazing per acre as compared with 1,997 hours by the next highest grass. *Paspalum plicatulum*, which produces a heavy sod spreading by rhizomes, is tender, promises to be a good pasture grass, and works into an attractive lawn. Three productive strains of Napier grass, resistant to eyespot (*Helminthosporium ocillum*), were being increased for distribution.

Bermuda grass.—Seed of Bermuda grass, according to Arkansas station studies, should not be planted before the daily temperature averages 65° F., and not covered deeper than 0.5 inch. Relatively

high mean temperatures and adequate moisture favored rapid growth of stolons.

Bluegrass.—Canada bluegrass × Kentucky bluegrass, according to a study by the Department (B.P.I.) and the Maryland station, is not as stemmy as either parent and has dark-green leaves intermediate in length and width, good vigor and spreading qualities, and produces seed under bag or with open pollination. Other promising strains of bluegrass were being multiplied by the Kentucky and Pennsylvania stations.

Brome.—Practical information on the characteristics of bromegrass (*Bromus inermis*) and its adaptation, cultural requirements, and usage and management for pasture, hay, rotations, seed production, and soil conservation, derived extensively from station experiments and experience, was published by the Nebraska station in cooperation with the Department (B.P.I.). Bromegrass was outstanding in yield of hay and pasture in experiments of the Iowa and Minnesota stations. Legume and grass mixtures containing brome were superior to other mixtures in Minnesota. Bromegrass also made high yields and was heavily utilized in North Dakota pasture studies.

Annual bromegrasses (*B. tectorum*, *B. rigidus*, and *B. rubens*) were found by the Nevada station to be valuable, especially in early growth stages. An average of 15 percent of protein was found in the early leaf stage and 10.5 percent in the dough stage. On areas completely protected for several years against grazing and on spring lambing grounds used intensively the annual bromegrasses have persisted year after year, surpassing most perennial grasses in this respect.

Millet.—Cultural and varietal tests over 30 years by the Colorado station in cooperation with the Department (B.P.I.) indicated the value of foxtail millet for dry land in eastern Colorado. It has not yielded well at high altitudes, and alfalfa and other crops have produced more and better forage on irrigated lands. Drilling from 25 to 30 pounds per acre of the Siberian variety just after a good rain between May 15 and July 1 and cutting for hay before or at first heading are advised. Highest yields have been obtained on fallow.

Hay.—Advantages of curing hay in properly made polestacks were brought out by the Michigan station. Green hay, a mixture of alfalfa, alsike clover, and timothy, free from rain or dew and averaging from 50 to 60 percent internal moisture when polestacked, cured in 14 days under adverse weather conditions to 19 percent moisture with no spoilage, while comparable cocked hay contained 27 percent moisture with a spoilage of 16 percent.

The high temperatures and humidities characterizing summer weather in Mississippi have made the curing of hay of good quality a difficult task. The Mississippi station observed that when alfalfa is cut during hot weather, the small pores in the leaves are closed preventing moisture loss essential to curing, but, when the hay is windrowed 2 hours later the lowering of leaf temperatures in the windrow enables the pores to reopen and give off moisture, with consequent speedy drying. Double windrowing 2 to 3 hours after cutting has furnished hay with better color, larger percentages of leaves, and lower moisture contents at the end of the day than curing methods commonly used.

Lawn and sport-field grasses.—Lawn practices recommended by the Ohio station in a comprehensive bulletin, based largely on experiments since 1927, involved seedbed preparation, seeding, soil treatments, cultural operations including mowing, influence of rainfall on growth, and grass species. The standard mixture used in the tests comprised Kentucky bluegrass 3 parts by weight, redtop 1 part, and white clover ¼ part.

Outstanding selections of velvet bent, based on quality and disease resistance, were increased by the Rhode Island station for observation under putting-green conditions. Several selections of creeping bent rated much higher than other bents for general turf quality in Pennsylvania station comparisons. The development of better strains of Kentucky bluegrass and red fescue has had a wide application to pasture use as well as for fine-turf areas.

Kentucky bluegrass at the Pennsylvania station responded markedly to phosphorus applications in the first year, while Colonial bent and Chewings fescue did not respond appreciably until the third and fourth year. With Kentucky bluegrass, organic nitrogen or split organic and inorganic nitrogen was more desirable than inorganic sources alone because of more even growth during the season.

PASTURES AND RANGES

The country-wide pasture programs in which practically all of the stations and the Department have participated have brought forth new and improved forage plants, more effective fertilizer methods, and better and more profitable management practices. The practical bulletins on pasture grasses and legumes, soils, fertilizers, planting methods, and management of pastures, published during the year by the Georgia, Nebraska, Virginia, and other stations on the basis of their experiments, are typical of the research findings made available to farmers and stockmen.

Fertilizers.—On permanent pastures in southwestern Virginia (Washington County), the Virginia station noted that phosphorus gave the largest individual increases in herbage yield on all soil types, and when used alone or with potassium and particularly with nitrogen decidedly improved the botanical composition. Use of nitrogen with phosphorus or with phosphorus and potassium did not depress the white clover content and gave the most marked early increases in herbage yield on all soils, with best improvement of botanical composition. Potassium used with nitrogen and phosphorus gave an additional increase in yield of herbage. Lime increased the herbage yield on strongly acid but not on moderately acid soils. Soil type and precipitation were also factors of importance. Satisfactory responses to phosphorus and lime, supplemented in certain situations by nitrogen, were also obtained in pasture studies of the Iowa, Mississippi, North Carolina, Pennsylvania, Tennessee, and Texas stations.

Carpet grass pastures in Florida station tests have responded to nitrogen carriers in total, early-season, and protein yields, but applications of lime, superphosphate, and potassium chloride were also found desirable to prevent phosphorus and potassium deficiencies. Annual light fertilization produced higher yields and better quality of grass than heavy treatments applied every 4 years. Proper fertilization greatly increased the mineral contents of the grass. Production of

Bermuda grass in pastures was proportional to the amounts of nitrogen available, the Georgia station reported. It concluded that nitrogen fertilization should be profitable on dairy farms, although growing clovers with Bermuda provides the cheapest source of nitrogen.

Application of nutrients to the soil surface without disking, the Pennsylvania station concluded from studies in cooperation with the Department (B.P.I.), is a very slow way to rebuild pasture because of the slow penetrability of fertilizer and manure into the soil. Plowing and disking in manure and minerals in quantity at one time is suggested as a short cut in securing a good pasture.

Pasture grasses and legumes.—Crested wheatgrass produced earlier and longer grazing, a higher carrying capacity, and more beef per acre than native species or bromegrass in dry-land pasture experiments by the Montana station. Crested wheatgrass might be used best for early grazing in conjunction with the native species used for finishing. Bromegrass has been intermediate in value. The Nebraska station found that grass strains from local sources or sources with an environment similar to that of Nebraska were superior to those from too far north or south or from high altitudes. Selections of little bluestem and big bluestem brought forward by the Kansas station appear superior to the ordinary types in all characters. These stations cooperated with the Department (B.P.I.) in their experiments.

Bermuda grass has been the most dependable pasture base in experiments at the cotton, rice, and fruit and truck substations in Arkansas, and Dallis grass was the most important grass supplement. Hop and white clovers and bur-clover produced the best results of the winter legumes while lespedeza, because of its better volunteering habit, was the most satisfactory summer legume. Carpet, Bermuda, Bahia, and centipede grass pastures, in grazing tests of the Florida station, produced 10 to 20 times as much beef as native grass pastures.

North Carolina station experiments showed the ability of lespedeza to increase yield and nutritive content of pasture herbage greatly when grown with Dallis, carpet, or Bermuda grass in the Coastal Plain. The season and species have been far more effective than soil treatment in changing the chemical composition of the herbage. Mineral fertilizer has added to the quantity of proteins and minerals present by increasing the percentage of lespedeza. Lespedeza in the sod has increased the phosphorus and added from 50 to 100 percent to the mineral content of the herbage.

Napier grass continued to prove its value at the Florida station for both beef and dairy cattle. Steers gained continuously during the entire growing period of this readily eaten grass. Furthermore, winter grazing tests with beef cattle showed that the dried grass, field cured, may provide a good winter feed. Napier grass is erect-growing and must be grazed rotationally; from three to five fields are needed for the purpose, and one or more cultivations each year are desirable. Water pasture studies, designed to use small shallow lakes and ponds adjacent to pasture areas, demonstrated the merits of water panicum and maidencane (*Panicum hemitomon*).

Management.—The importance of careful management of pastures was emphasized by the Arkansas station, which demonstrated that pasturage is a sizable annual farm crop and that sustained production requires planned management. Rotation grazing, a management

practice of increasing importance, has improved the stand and productivity of bluegrass pastures in Missouri station experiments in cooperation with the Department (B.A.I. and B.P.I.). About 60 percent of the gains by cattle for the season on bluegrass have been made during the first 2 months of grazing, when it is most palatable and nutritious. Gains made on bluegrass July to September were surpassed by those on Korean lespedeza, and gains made in October were exceeded on winter barley.

Pastures rotationally grazed, the Minnesota station and the Department (S.C.S.) reported, will give higher yields when grazed at heights of 8 or 12 rather than at 4 inches, a principle applicable also to permanent grazing. At the New Jersey station close grazing, followed by two or three mowings a year, has helped to eliminate weeds and reduce the population of unpalatable grasses.

The Kentucky station demonstrated the value of moderate to close grazing as compared with undergrazing in producing sods of low weed content and maintaining white clover.

The Illinois station cooperating with the Department (S.C.S.) reported that vegetative cover on land treated with limestone and phosphorus and with regulated grazing was from three to four times greater than on land grazed intensively, but that the cover did not increase much on untreated land. Severe grazing and lack of soil treatment encouraged undesirable vegetation, but even under such conditions soil losses from land with established vegetal cover were slight. Level terraces were not effective in increasing yields or quality of pasture on upland Norfolk sandy soil of low fertility in Alabama station tests, although they reduced the run-off about 50 percent and therefore were desirable for conservation.

Burning.—It appears that the effects of burning pasture may depend upon the type and the location of growth. Burning makes the early spring growth of grass more available and possibly more palatable to animals, according to Oklahoma station work in cooperation with the Department (S.C.S.). This advantage, however, may be more than offset by a reduction in quantity and quality of forage produced over a period of years, by destruction of plant nutrients and organic matter, by increased losses of soil and water, and by damage to fence posts and other equipment. Controlled periodic burning of native-grass pastures by the Florida station cooperating with the Department (B.P.I.) has increased their grazing value by about 45 percent as compared with protected pastures.

Advantages from pasture improvement and good management practices of the Georgia station cooperating with the Department (B.P.I.) in a comparison with unimproved pasture included increases that were about double the animal gains per acre, greater weight and body size in mule colts, lowering of production costs of milk by about one-half, doubling the production of total digestible nutrients per acre at a cost per 100 pounds of about one-fourth that from commercial feeds, and increasing the organic matter of the soil about 4,355 pounds per acre over idle land and 13,620 pounds over cultivated land.

Ranges.—Information on range resources and their management and improvement was increasingly sought by range livestock men and also by agencies studying tax problems in range areas and yet

others interested in soil conservation. Of three grasses producing good stands from seedings on the New Mexico station ranch, 1938–40, Lehmann lovegrass, from South Africa and apparently most promising, could establish itself even in dry years, reseeds readily, and produces a large forage yield. Rothrock grama also has made a sizable amount of forage in favorable years and thrives about as well as in its native southern Arizona. Blue lovegrass compared favorably with a good stand of native range grasses in average production. In securing stands, listing with a 2-row lister on the contour with horizontal intervals of from 3.5 to 5 feet and trailing with a 6-foot drill to plant the seed appeared most satisfactory.

Wide differences in the responses of the four principal grasses to grazing and climate were observed by the Arizona station cooperating with the Department (F.S.). Black grama increased consistently in density under protection from grazing, but showed a slight decline under controlled grazing. Cotton grass showed wide fluctuations due to climatic changes, but exhibited little effect of grazing. An inferior species, poverty grass, increased in density under all grazing conditions, while the short-lived Rothrock grama fluctuated widely due to climate.

Severe drought, overgrazing, burial by dust, and grasshopper damage in recent years have resulted in great reduction of the cover of range grasses in the Great Plains. Study of selected grassland areas by the North Dakota station cooperating with the Department (B.P.I., B.A.I., and S.C.S.) showed that the range had not yet recovered completely from the severe droughts in 1934 and 1936, the density of forage cover still being below that before these droughts. Forage yields demonstrated a definite advantage in contour-furrowing pasture, the improvement being due largely to increased yields of the taller grasses, as western wheatgrass. Good forage cover could be established on abandoned fields by natural revegetation within 10 years after abandonment, but 50 to 75 years would probably be needed for complete revegetation. Combination of drought and continued heavy grazing was found by the Colorado station to be very detrimental to the better range grasses in eastern Colorado. The damage by grasshoppers during drought has also been a factor of great importance to the range livestock operator.

WEED CONTROL

Control or eradication of the weed pests of cultivated and broadcast crops, gardens, meadows, pasture, range, and lawns continued to be an increasingly important field of research carried on by most of the experiment stations. Weed manuals and other publications reporting their investigations on particular weeds were issued by several stations during the year. Selected examples of progress in current research with weed plants are given in the following paragraphs.

Bindweed.—Study of the structure and growth habits of the bindweed, by the Kansas station and the Department (B.P.I.) cooperating, provided information essential in setting up a control program for the State.

Cultivating at 8-day intervals after bindweed plants emerge decreased the labor needed for eradication, in studies by the Minnesota station and the Department (B.P.I.). The percentage of readily available carbohydrates in the roots fell rapidly from emergence about May 1 to a low point in June. Consequently, cultivation for control need not begin until early June. Alfalfa and grass and legume mixtures with alfalfa as a base reduced bindweed stands, and a season of fallow followed by soybeans, millet, Sudan grass, sorghum, or corn drilled solid was effective in eradication. According to the Nebraska station destruction of bindweeds by tillage accomplished when plants were allowed to grow for 8 to 12 days required less work and was more effective than cultivating oftener.

Bindweed-control tests by the Colorado station, involving sodium chlorate, suggested a 2-year control period; limiting chemical treatment to areas of 0.25 acre or smaller; uniform distribution in dry form between July 1 and frost, preferably from August to October; and a 3-pounds per square rod initial rate in the first season, followed with the quantity needed by return growth in the next season. Optimum time of applying sodium chlorate has varied with the locality of the station.

Fishpond weeds.—*Najas guadalupensis* has been controlled in fishponds at the Alabama station by the use of inorganic fertilizers which induce a heavy growth of algae, apparently shading out the weed. Fertilization also improved the production of fish food, growth of fish, and ease of fishing.

Lawn weeds.—Control measures for 26 species of weeds infesting lawns and waste places near lawns, and ways to renovate lawns badly dmaged by weeds, were published by the Ohio station from its studies, 1928–40, on their elimination by chemicals, cultural practices, and seed control. Special attention was given to dandelion, broad-leaved plantain, buckhorn, and crabgrass, the worst lawn weeds in the State.

Nutgrass.—A system of nutgrass eradication developed by the Arizona station comprises disking 3 inches deep about April 21; plowing 6 inches deep about May 14, 9 inches about June 7, and 12 inches deep about June 21; irrigations July 7 or after; and planting hegari. The tubers are brought to the surface and killed by drying and heat.

Whitetop.—Cultivation with the duckfoot cultivator at intervals of 1 to 4 weeks has eradicated *Lepidium repens* in 2 years in Washington station experiments. Reasonably good crops of corn, potatoes, sugar beets, and alfalfa could be raised on land heavily infested with the weed, and rye was particularly useful for crop competition. Carbon bisulfide has given complete kill of *L. repens*, which also is more susceptible to sodium chlorate than *Hymenophysa pubescens*, the other form of whitetop. The Utah station found smooth bromegrass and reed canary grass very effective as smother crops.

Herbicides.—Sinox when sprayed by the North Dakota station on flax nearly in bloom was most satisfactory for general use in a 1:100 concentration, particularly for the eradication of mustard. Sprayed flax averaged 10.68 bushels per acre and untreated 4.59 bushels. Water pod, marsh-elder, ragweed, field mustard, French weed, and wild buckwheat were readily killed. Sinox was effective on the mustards and wild buckwheat without injury to flax in Minnesota station studies, and gave good results on crabgrass and mouse-

eared chickweed in lawns. An emulsion containing Sinox in aqueous phase with diesel oil has been a cheap method for control of vegetation on roadside and ditchbanks in studies by the California station and the Department (B.P.I)

Sodium fluoride dust injured smartweed in Tennessee station tests without harm to tobacco leaves. A solution of sodium fluoride (2 percent) and soap powder (1 percent) gave good control of crabgrass in lawns without permanent injury to bluegrass. Quick-growing, succulent annuals with thin cuticle are most susceptible, while perennials do not seem to be injured easily. The chemical, for best results, should be applied early in the season while plants are tender and the cuticle is thin and permeable.

Soil sterilants.—Appraisal of the typical herbicidal behavior of several chemicals was made from extensive experiments of the California station which have suggested dosages for soil sterilization in practical weed control. Sodium chlorate added to arsenic trioxide or to sodium arsenite has combined its rapid action with their lasting properties. Since chlorate acts on deep-rooted perennials, the mixture provides an effective treatment where both deep- and shallow-rooted plants abound. Borax and colemanite have more lasting effects than chlorate but less than arsenic; they do not have the high inherent toxicity of these herbicides, yet have been successful against Klamath weed and bearmat, and being nonpoisonous to livestock may be used without hazard on ranges.

Soil sterilization in perennial weed infestations by fall application of sodium chlorate leached into the soil by irrigation was proved practicable by the Arizona station. Sterilization of border and fence row soil with chlorates and borax gave very promising results.

HORTICULTURE AND FORESTRY

CONTENTS

FRUITS AND NUTS

Varietal improvement.—Important contributions were made by several of the State stations in the development of improved varieties of fruits. From a cross of Halehaven by Kalhaven, the Michigan station obtained a new variety of peach, Redhaven, which ripens about 1 month earlier than Elberta and has yellow flesh and a free stone. In appearance the Redhaven is very attractive, the exterior color being a bright yellow usually almost completely overlaid with a brilliant red. Because of its early ripening and good quality it is considered a very promising new variety.

A new variety of red raspberry, Tennessee Autumn, obtained by the Tennessee station from a cross of a hybrid (Latham × Van Fleet) and Lloyd George, was reported as promising because of good-quality fruit and the ability of the plants to retain their leaves under conditions which defoliate most other kinds of raspberries. The new variety is expected to make possible a profitable red raspberry production in Tennessee.

Cultural methods.—A comparison by the Michigan station of various planting systems for strawberries showed in general that the spaced plants were most productive of marketable fruit. There was some variation in the response of different varieties. With varieties such as Dorsett, Fairfax, and Catskill, which naturally produce large crowns, a 6- to 8-inch spacing appeared desirable, while for Dunlap, with smaller crowns, a 4-inch spacing may suffice.

The Arkansas station reported that blackberries are inherently more resistant to winter cold than are dewberries and raspberries. Warm periods in the field after February 1 caused a dangerous condition by stimulating growth in buds and living tissues. Although heavy manurial treatments tended to result in increased winter injury, the harm was more than offset by the greater cane development on the manured plats.

Investigating the causes of the poor development of peach trees when replanted directly on sites from which old peach trees had been removed, the California station found that peach-root residues are detrimental to the growth of the young trees. The bark rather than the wood of peach roots was toxic, but the identity of the specific toxic compounds was still unestablished.

Some evidence was found by the Minnesota station that early mulching may actually endanger strawberry plants by preventing their natural hardening. Plants from the later-mulched lots proved superior in their capacity to resist low temperatures. Exposure to autumn frosts, but not to heavy freezes, was desirable rather than harmful.

Nutritional investigations.—The application by the New York (Cornell) station of potassium to McIntosh apple trees about 10 years of age and exhibiting weak growth, scorched leaves, and limited fruit production, was not immediately effective, but by July of the next year there was improved growth, better color of the leaves, and conspicuously less scorch.

Observing that peach trees fertilized with nitrates following harvest made greater spring shoot growth than those not so treated and that, irrespective of nitrogen treatments, the trees tended to arrive at similar low levels of nitrogen concentration during shoot elongation, the North Carolina station suggested the need on light sandy soils of applying nitrogen during summer and fall. There was no indication of late-continued or second growth caused by late-summer applications of nitrogen, and such treatments proved beneficial by delaying the onset of dormancy. No winter injury was observed during the 5 years of the experiment. Nitrogen had a very direct influence on the quantity and quality of foliage.

Propagation.—Evidence that the parentage of the seedlings used as rootstocks may affect the size of the resulting trees was obtained by the Pennsylvania station and the Department (B.P.I.) in obser-

vations on 11-year-old apple orchards established with commercial varieties on known roots. In one orchard, Delicious seedlings produced considerably larger York Imperial trees than did Gano, Ben Davis, or French Crab seedlings. In another location, Wealthy seedlings produced larger York Imperial trees than did Winesap, Winter Banana, or Golden Russet seedlings. A large loss of Gallia Beauty trees worked on Red Siberian Crab indicated marked incompatibility between the stock and the scion.

In trials by the Iowa station in cooperation with the Boyce Thompson Institute, using approximately 50 species and varieties of horticultural plants, it was shown that herbaceous cuttings almost without exception responded favorably to treatment with a proprietary substance containing indolebutyric acid. The rooting response of greenwood cuttings of many species of deciduous trees and shrubs was variable and was influenced by prevailing climatic conditions. In general, results with hardwood cuttings were unfavorable.

With grapes, such as Concord, Moore Early, Campbell Early, Delaware, Sheridan, and Ellen Scott, grown on their own roots and on different rootstocks, the Missouri Fruit station observed that the yield of certain varieties may be greatly increased by propagation on vigorous rootstocks. For example, Campbell Early produced four times as much fruit on the most effective rootstock as on its own roots. Other varieties, such as Moore Early and Concord, did not respond as markedly in fruit production but made strong vine growth, which should mean increased yields in later years. No appreciable difference in quality of fruit or in time of ripening was recorded.

Physiological studies.—The harmful effect of excess water in the soil on the life processes in fruit trees was shown by the Ohio station, working with young apple trees. Certain trees showed definite reductions in photosynthetic activity the first day after flooding. The results support the accepted horticultural practice of planting trees on naturally well-drained sites where long-continued flooding of the soil is impossible.

That the temperature of the soil exerts a pronounced influence on the rate of water loss from the leaves of young orange trees was established by the California station in an experiment with Valencia trees. As the soil temperature was reduced from 90° to 43° F. there was a marked reduction in water loss from the foliage.

Further evidence was presented by the New York (Cornell) station on the efficacy of naphthaleneacetic acid and naphthaleneacetamide sprays in reducing the preharvest drop of the McIntosh apple. Unsprayed trees in a closely planted, heavily fertilized orchard dropped 48 percent of their fruit from September 17 to 28, while comparable trees sprayed twice with naphthaleneacetic acid dropped about 6 percent.

In a study of the effect of coating Grimes Golden and Golden Delicious apples with wax emulsion, the Maryland station recorded a significant reduction in weight loss in the treated fruit during and subsequent to storage. The effectiveness of the wax treatment was shown in a reduction in the number of wilted fruits that had to be culled at the end of the storage period.

Evidence that increased content of carbon dioxide in the storage atmosphere is helpful in keeping strawberries was obtained by the

New York (Cornell) station. The results indicated that a temperature of 50° F. and 15 percent of carbon dioxide in the storage atmosphere was the most desirable treatment. Sweet cherries were also successfully handled in gas storage.

VEGETABLES

Varietal improvement.—Notable progress was reported by certain stations in the development of better adapted varieties of vegetables. The Tennessee station produced the Essary tomato which over a 3-year period, 1938–40, outyielded both Certified Marglobe and Certified Indiana Baltimore in average yield of U. S. No. 1 fruits.

Victor, a new tomato bred by the Michigan station, was found to possess the determinate growth habit of the Allred and the smoothness of the fruit of Break O'Day, and is recommended for trial as an early market tomato for Michigan. Using the same parents, the North Dakota station developed the Bounty tomato, a promising early, determinate vine variety, characterized by good yields of well-shaped fruits free from dark-green overcolor at the stem end.

The Alabama station was successful in the selection of insect- and disease-resistant plant materials from the old orchards and gardens of the State. For example, there were located a pole variety of bean with marked resistance to root nematodes and drought and 3 strains of onion that withstand low winter temperatures.

Cultural methods.—Well-grown tomato plants produced in the South and shipped to northern canning-crops areas may produce more satisfactory yields than direct-seeded fields of the same variety, according to results of the Iowa station.

That spacing of sweet corn plants may exert considerable effect on total yields of ears and on the quality of the individual ears was shown in experiments conducted by the Maine station. There appeared to be an optimum spacing for any given variety. Too close planting resulted in many barren plants, and extremely wide spacing permitted the development of small secondary ears which reduced the percentage of desirable ears.

Nutritional studies.—Absorption of nutrients by the Perfection pimiento pepper increased slightly in the second month and attained a peak in the third month, according to the Georgia station. The results suggested that the greater part of the fertilizer should be placed under the plants a few days before setting and the balance used as a side dressing in late June.

A well-defined relation of soil type to the effectiveness of fertilizer applications to onions was reported by the Texas station.

Boron deficiency, as evidenced by growth response to borax or by malnutrition symptoms, was observed by the Virginia Truck station in at least 16 vegetable crops in eastern Virginia. With a majority of the vegetables under test applications of borax resulted in increased yields or better quality. Certain of the light Norfolk soils were found extremely deficient in boron, but this condition was not general with the majority of eastern Virginia truck-crop soils.

Physiological studies.—That cucumber seed requires a warm soil for germination was shown in stands of 25, 37, 79, 85, and 96 percent of plants recorded by the Michigan station for sowings at East Lansing on May 21, June 1, 10, 20, and 30. Yields was highest from the June 10 planting.

Fruits of John Baer, Marglobe, King Humbert, and Golden Queen tomatoes, taken from plants grown by the New York State station with abundant and limited quantities of soil moisture, were affected in acidity by the moisture environment. Dry conditions tended to increase and moist conditions to decrease acidity.

Analysis by the Nebraska station of Nantes and Chantenay carrots sampled at intervals throughout the growing and storage seasons showed certain varietal differences in composition, the Chantenay roots being consistently sweeter than Nantes and the differences becoming more marked in storage. In both varieties, carotene per unit of fresh weight was always higher in the phloem than in the xylem tissues.

FORESTRY

Silvicultural studies.—A study by the Arkansas station of small ownerships and second-growth hardwoods showed that these holdings are rarely managed for sustained yields and are often cut for immediate cash returns with no thought to the future. As a result, there is an inefficient use and depletion of Arkansas hardwoods except by a few large mills in the bottom lands. There is an evident need for an effective State-wide fire-protection plan and for education of forest owners and dwellers as to the possibilities of good management.

Recognizing the important role of mountain forests and vegetation in maintaining the vital water supply for the agricultural and urban communities in the valleys, the Utah station studied the extent of forest and watershed fires in the State. There was found an urgent need of fire prevention and better management practices. Among the serious after effects of fires are floods, erosion of the surface soil, damage to highways, and the destruction of wildlife.

Studies made by the Vermont station in a 28-year-old plantation of jack and Norway (red) pines, the trees of which were spaced 2 by 2, 4 by 4, 6 by 6, and 8 by 8 feet, showed the horizontal roots to be concentrated mainly in the A_1 horizon regardless of the degree of competition due to the density of spacing. Ninety percent or more of the horizontal roots were located above the lower limits of the B horizon. Most of the horizontal roots were less than one-half inch in diameter. Both the jack and the Norway (red) pines developed strong vertical roots, those of the Norway (red) pine being larger in diameter and penetrating more deeply than those of the jack pine.

According to observation by the Minnesota station in the central part of the State, permanently compacted subsoils restricted rooting mainly to the superimposed soil horizons, with the degree of confinement depending on the degree of compaction. The irregular growth habit exhibited by the roots of bur oak growing under normal soil conditions is attributed to hereditary characteristics rather than to any external factors.

The death of top limbs of isolated pasture trees, observed by the Michigan station, was ascribed to root injury caused by the concentration of farm animals seeking shade. The trampling by the animals injured the roots and compacted the soil to a harmful degree. Trees

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protected from animals and pruned of their deadwood were restored to a thrifty condition.

A comparison by the Indiana station of records of wind velocity taken near a four-row Norway spruce windbreak before and after natural pruning had occurred on the interior trees showed only a very slight loss in efficiency resulting from the disappearance of the interior foliage. The two outer tree rows had maintained their foliage to a satisfactory degree.

A survey by the Michigan station of the damage in 10- to 13-year-old blocks of coniferous species following a winter of exceedingly heavy snowfall, totaling 128 inches, showed the injuries to consist almost entirely of the breaking away of lower lateral branches below the snow level. In order of decreasing injury were red pine, white pine, white spruce, Norway spruce, and Scotch pine. Generally the smaller trees were more severely injured, especially when surrounded by larger trees.

Nutritional studies.—In studies by the Wisconsin station a pronounced increase was noted in the rate of height growth of *Pinus banksiana* and *P. resinosa* correlated with a higher content of organic matter in the soil. A close relationship was established between the content of organic matter and that of total nitrogen, available phosphorus, and available potassium in outwash and pitted outwash sandy soils derived from granitic rocks. There was noted also a general tendency for the increased survival of seedlings on soils high in humus, but the correlation was not significant.

According to the Wisconsin station the application by broadcasting or in solution of a balanced N–P–K fertilizer to nursery beds of average fertility resulted in an average increase in survival of from 10 to 16 percent following transplanting of 2-year-old jack, red, and Scotch pine seedlings to a podzolic outwash sandy loam. The average increase in height growth ranged from 20 to 30 percent in favor of the fertilized stock.

The application, by the West Virginia station, of a small amount of a 4–12–4 fertilizer at a 6-inch depth near the roots caused black locust trees to make more than twice the annual height growth of the controls. The black locust grew faster than the weeds. The station suggests that other species which start slowly and are intolerant of shade should not be fertilized the year of planting unless weed control is practiced.

Propagation.—Based on studies with seed of 34 different species of conifers the New York State station reported that the various species have characteristic requirements for successful germination. Average germination percentages varied greatly with genera and species, with most of the pines between 70 and 90 percent viable while larch seed seldom gave over 50 percent. Moist prechilling was found essential for certain pine and larch species and for eastern hemlock, and was probably desirable for other species. Daylight was necessary for satisfactory germination of some species, and evidence was obtained that artificial light may be helpful in attaining complete germination in certain Scotch pine stocks.

Good results were obtained with white pine cuttings taken by the Massachusetts station in March from the upper and lower portions of a tree about 30 years old and treated variously with indolebutyric acid and sucrose before placement in a sand-peat moss bed in a warm

greenhouse. At the end of 3 months, when the untreated controls were mostly dead, cuttings which had been given a preliminary treatment with sucrose and a final treatment with a solution of 50 micrograms of indolebutyric acid per liter of water showed considerable rooting.

The value of growth-promoting substances for inducing the rooting of both narrow-leaved evergreens and softwood deciduous cuttings was reported by the Ohio station. Growth-promoting substances incorporated with talc were found almost as effective as solutions and possessed the advantage of easier application and a wider range of effective and safe use. The fineness of the talc and the method of mixing made appreciably little difference. Moistening the base of cuttings in water before dipping in powder was important.

AGRICULTURAL SOILS AND PLANT NUTRITION

CONTENTS

The increased demand for many products obtained either directly or indirectly from the soil calls attention to the accomplishments as well as the future need of soil-science research. Greater production may be accomplished through the use of improved methods on land suited for intensive management or by increasing the amount of land used for crops and livestock. Experiences of the past as well as the results of current research show the effects in soil wastage and destruction of fertility through wind and water erosion which may follow the extension of production to unsuitable areas. A better course is the use of more efficient methods and additional research to indicate new possibilities for more economical production.

Among other accomplishments, during the last year soil-science and plant-nutrition research has added to our knowledge of the relation of certain elements used in small quantities by plants to the effective utilization of elements used in larger quantities. Investigations of various fertilizer materials and methods of application of fertilizer, including liquid fertilizers, point the way to greater and more economical production through the use of concentrated fertilizers and proper placement of fertilizer in relation to the growing plant.

Studies of chemical and physical properties of soils have resulted in increased knowledge of the effect of various soil properties on the quantity and quality of crop produced. Among the physical properties might be considered many of the factors which affect soil tilth. Increased knowledge of tilth has shown the relation of soil air in some of the heavier soils to crop yield. Soil aggregation or crumbiness, another factor of tilth, has been investigated with the result that the specific effect of certain soil treatments has been isolated.

Organic material added to the soil from vegetation grown thereon has been found to be effective in maintaining the productivity of some

southern Coastal Plain soils. Additional knowledge about the action of various micro-organisms in the soil has shown that certain organisms produce substances harmful to other organisms. Additional results on the value of various soil conservation practices are providing information basic to the establishment of sound programs of land use.

The following pages describe some of the typical findings of soil-science research during the last year.

SOIL REACTION AND ITS CONTROL

In one or another of its various aspects, the problem of the most favorable soil reaction for optimum crop response is almost constantly under investigation. The range within which a particular crop grows best is generally rather narrow.

For example, the Rhode Island station found the crop itself to cause small but significant increases in the acidity of normal soils. Of the crops tested, timothy had the least effect, while onions, clover, and carrots induced progressively greater increases in acidity and beets brought about a still greater rise. The increase in soil acidity was traced to an accumulation of unused fertilizer components, and the detrimental effects were progressive. As would be expected from the association of the increased acidity with fertilizer residues, non-acid-forming fertilizers benefited the beets most, timothy least, and the three other crops to an intermediate degree. When lime sufficient to produce optimum growth was used, there was little accumulation of unused plant nutrients and little change in soil reaction.

The value of non-acid-forming fertilizer mixtures is being more and more realized. A report from the Vermont station shows, for example, that non-acid-forming mixtures constituted 17.7, 20.1, 21.8, 26.1, and 33.3 percent, respectively, of the total fertilizer tonnages sold in Vermont in the years 1936 to 1940, inclusive. The addition of about 500 pounds of dolomitic limestone to an otherwise acid-forming fertilizer at the Mississippi station cost about 30 cents per ton, practically eliminated soil acidification, and raised seed cotton yields by about 90 pounds per acre on soils of a sandy texture while heavy soils showed no response. In soils presenting a problem rather of excess alkalinity than of acidity, acid-forming fertilizers may have a definite value. On a Salt Lake sandy loam soil containing a small proportion of "black alkali," which is characterized by the presence of strongly alkaline substances, mainly sodium carbonate, the Utah station found acid-forming materials to effect a small increase in the yield of alfalfa.

Because much grassland is not tilled, the Connecticut (Storrs) station investigated the effectiveness of lime applied on the surface of such land as compared with that of lime applied on tilled fields. Penetration was much more rapid in the tilled soil. The results on the grassland indicated that it would take 10 years for a surface application of 2 tons of limestone to produce a reaction change uniform through the first 6-inch layer. The effectiveness of surface application of limestone in the northeastern United States is considered to be sufficient, however, to make this method of liming a more desirable one than that of mixing the liming material with the soil of permanent grasslands. From somewhat similar studies samples of 12 soil types transferred by the New Jersey station to small experimental

areas and planted to grass, it was found that one ton of finely ground limestone per acre produced as much effect below the surface inch in a year as did the same quantity of hydrated lime in 1½ years. The hydrated lime caked and dissolved more slowly than did the limestone, whereas the limestone remained finely divided under all moisture conditions.

The California station, pointing out that plants do not commonly grow in soils containing as much water as is usually added to a soil sample of which the reaction is to be determined, reported the development of a method for determining soil reaction in samples of a moisture content comparable to that found under natural field conditions.

MINERAL NUTRIENTS, AVAILABILITY, FIXATION, AND BASE EXCHANGE

Progress in the rapid diagnosis of fertilizer deficiencies in soils has been made through the application of plant-tissue tests by the New York State station. The advantage claimed for the plant-tissue test over soil analysis is that the former gives direct information on the availability of the nutrients for plant use and as such is especially valuable for determining whether areas are suitable for increased production.

Among the noteworthy modifications in fertilizer practice is the use by the same station of starter solutions for transplanted plants, made from highly concentrated water-soluble fertilizer salts. A starter solution costing about 80 cents per acre hastened the maturity of tomatoes and increased total yields by over 1.5 tons per acre.

The Missouri station reported that germination injury sometimes resulting from the use of fertilizers may be largely overcome by the use of calcium. Fertilizer effectiveness may thus be improved by adding calcium either to the fertilizer mixtures or to the soil.

The use of fertilizers of higher plant-food content has continued in many States and extended to several others. The Indiana station found that the use of complete fertilizers containing 20 or more units per ton, first recorded in 1927, increased to more than 4 times as much in 1930, dropped sharply in 1931 and 1932, and rose from 1933 to 1939 when the figure was more than one-fourth greater than the 1930 maximum. One of the contributing factors leading to the use of more concentrated fertilizers reported by the Texas station is that plant nutrients in this form cost less per ton. The use of higher analysis fertilizers also reduces the shipping space required for transporting the required plant nutrients.

The many phases of the phosphorus problem involving forms of phosphorus in the soil, availability of different carriers, possible mechanisms of phosphorus fixation, and penetration of phosphorus in the soil continued to occupy a prominent place in the program of several stations. In an attempt to obtain basic information essential to the formulation of phosphorus fertilizer recommendations for Iowa soils so as to obtain maximum production, the Iowa station examined in detail 12 soils, representing 11 soil series, for total phosphorus, dilute acid-soluble phosphorus, and pH. Total phosphorus was found to decrease with depth to a minimum in the lower A or upper B horizons and to increase below the zone of the lower A and to continue to increase until the C horizon, which was found to have the greatest

amount in most cases. The dilute acid-soluble phosphorus was found to follow a trend similar to the total phosphorus in 9 of the 10 soils studied.

Development of processes for combining phosphorus with various fertilizer ingredients to obtain more concentrated carriers has prompted investigations to determine the probable effect of the combination on the movement and availability of the plant nutrients. For example, in a laboratory comparison the Delaware station used Chester loam and Sassafras sandy loam and Sassafras sand treated with calcium metaphosphate, potassium metaphosphate, superphosphate, and triple superphosphate and leached with 50 inches of water. No appreciable movement of phosphorus occurred beyond a depth of 3 inches except in the sand, but the penetration of phosphorus in the soil was greater with superphosphate than with the metaphosphates. The potassium of potassium metaphosphate was more mobile than the phosphorus. Availability studies gave no evidence that the metaphosphates are capable of furnishing a supply of available phosphorus to plants over an extended period, and the fixation of phosphorus in unavailable forms was greater in the soils receiving metaphosphate than on soils receiving superphosphate. However, the use of metaphosphates might prove advantageous in light sandy soils since they are less subject to losses by leaching than is superphosphate.

The results of experiments with granulated phosphates by the Arkansas station showed that the larger and harder the granule the greater the availability of the phosphorus in the fertilizer. It is suggested that on soils having a high phosphate-fixing capacity granulated phosphates should produce greater yields than those obtained with phosphates in the ordinary form. Granulation may partly overcome phosphate fixation by localizing the fertilizer near the roots of plants, but the Alabama station found from greenhouse and field experiments that powdered forms applied locally near the plant produced as much plant growth as was obtained with the granulated forms and often more.

The action of the clay minerals kaolinite and montmorillonite on phosphate fixation in an unavailable form was investigated by the Oklahoma station. Kaolinite was found to contain practically no water-soluble phosphate, and plant studies further substantiated the evidence of low availability of phosphorus in the kaolin complex. Montmorillonite, on the other hand, contained considerable water-soluble phosphate, and the complex did not decrease the availability of applied phosphorus when the tomato was used as the indicator plant. The effect of soil acidity, free iron and aluminum oxides, and degree of base saturation on phosphorus fixation was investigated by the Wisconsin, Kansas, Colorado, New Jersey, South Carolina, and Alabama stations. In general the results indicated that within the pH range of most acid soils fixation is due to the formation of iron and aluminum phosphates, while in the neutral to alkaline condition in high-calcium soils there is precipitation as tricalcium phosphate.

Some of the investigations on potassium included rate of absorption by plants, the relation of potassium to crop production, potassium fixation in soils, and the effect of different soil treatments on leaching of potassium. The Arkansas station, working with plants in culture solutions, found that plants are able to make satisfactory growth on

very dilute concentrations of potassium in solution as long as that concentration is maintained.

In a study of eight soil types, the Alabama station determined the effect of soil characteristics and winter legumes on the leaching of potassium below the 8-inch layer. Soil texture and type of plant grown were found to have an important effect on potassium leaching. Winter legumes were effective in reducing the leaching of potassium by 17 percent of the total potassium applied, in addition to reducing erosion and supplying nitrogen for succeeding crops.

SOIL DEFICIENCIES AND TOXICITIES

As with nutrients utilized in much larger quantities, deficiencies in the soil supplies of the trace-requirement elements may result from simple exhaustion or erosion or from either natural changes or management practices which make the existing supplies unavailable.

An interesting explanation of a boron deficiency of the last-named type has been brought to light by the work of two stations. In an investigation of overliming injury, the Vermont station had previously found that overliming acid soils converted a part of the soil organic matter into substances injurious to growing plants. At the same time, the Alabama station showed that overliming the soils on which it was working made unavailable the necessary traces of boron. The Vermont station has now tied together these seemingly quite different observations by showing that the injurious organic compounds which it had found combined with soil boron compounds to form complexes from which the plant could not extract even the traces of this element which it required. Boron may also be rendered unavailable to plants, if too much lime be applied, by the physical process of "adsorption," or a concentration on surfaces of soil particles. Another little-understood phase of the relation of boron to crop production has been successfully attacked by the New Jersey station, which has shown that plants supplied with optimum quantities of boron make better use of the available calcium than when provided with less than their requirement of boron. Even when the calcium supply becomes deficient an adequate supply of boron keeps the calcium already in the plant in a condition to be carried about from one part of the plant to another and utilized, whereas the absence of adequate quantities of boron causes immediate symptoms of the calcium deficiency. Small quantities of calcium in the plant tissue permitted better yields when accompanied by suitable quantities of boron than did relatively large uptake of calcium without sufficient boron. In potato growing, an inadequate boron supply resulted in tubers which turned dark inside when boiled or baked. At the Michigan station, calcium and magnesium carbonates were found to cause a fixation of the soil boron in a form that did not supply this element to soybeans. Soybeans were injured quite easily by excess of boron applied as borax, the toxicity symptoms being easily recognized yellowish-brown spots around the edges of the leaves. The addition of boron compounds to fertilizers was found by the North Carolina station to increase crop tolerance for lime, to reduce the fertilizer requirement (in some instances by one-half), to improve the quality of all major truck crops and flowers, to make usable some otherwise unproductive lands, and to increase the variety of crops which can be grown.

Excess of boron has been shown by the California station to cause manganese deficiency, corrected by treatment with maganese compounds. A manganese deficiency which did not cause any deterioration in the quality of the fruit brought about a serious drop in the yield of orange trees at the same station. Either lack of phosphates or excess of potassium accentuated the effects of this deficiency. In lemon trees, excessive concentrations of manganese salts in the sprays used to correct manganese deficiency readily produced symptoms of manganese toxicity. Deficiency either of zinc or of iron was found capable of masking the evidence of manganese deficiency until both zinc and iron were supplied in adequate quantities. Color photographs of boron deficiency symptoms in orange trees were prepared by the station.

A zinc deficiency has been found by the New York (Cornell) station in certain peat soils. Lack of the requisite traces of zinc was found by the California station to alter profoundly the internal structure of the growing parts of plants and to render the chemical products of the life process abnormal.

Several of the stations conducted tests with different local material to determine their value for supplying one or more of the minor elements. As an example of determining the value of a specific material as a source of minor elements, the Wisconsin station found in studies with corn, sunflower, and tomato plants with dried sewage sludge sold under the trade name of Milorganite as the only source of copper, zinc, manganese, or boron that either as a fertilizer or as a part of a mixed fertilizer this material may be used as a source of these elements.

Neither magnesium nor sulfur are trace-requirement elements, properly so-called, both being present in a healthy plant in relatively large quantities. They are dealt with here, however, because a lack of either may produce definite deficiency-disease symptoms and reduced yields.

The magnesium content of commercial superphosphates was found sufficient by the Alabama station for normal plant growth in greenhouse experiments on most soils, but in the most deficient soils some plants were only slightly benefited by such magnesium as they could obtain from superphosphates.

Sulfate supplies in certain western soils have been found insufficient to meet the sulfur requirements of some crops, and a disorder of alfalfa has been traced to such a deficiency of sulfur compounds. The California station found sulfur deficiency to appear most frequently in the growing of legumes. Marked plant response to numerous sulfur compounds was observed, organic as well as inorganic sulfur sources being included.

Toxic effects of arsenates and chlorates in soils have been studied by the Washington station. A failure of crops in old orchard soils from which mature trees had been removed was shown by this station to be due to soluble arsenic in the surface soil. Application of 3,000 to 9,000 pounds of ferrous sulfate per acre was sufficient to permit the growing of alfalfa on a soil which contained soluble arsenic enough to render it highly toxic. On a soil already high in phosphorus the use of 2 to 4 tons of superphosphate was not as effective as the iron sulfate treatment above mentioned. In soils of only mild arsenic

toxicity, dilution of the arsenic concentration in the surface soil by subsoiling was effective, little arsenic being present in the subsoil. In soils of medium to high arsenic toxicity, dilution by tillage, together with application of iron sulfate or superphosphate, or both, may be necessary.

ORGANIC MATTER AND NITROGEN

The Utah station reports that, because of the original low level of nitrogen, together with the depleting characteristics of the alternate wheat and fallow system, soil nitrogen rather than moisture may be the limiting factor of crop production in certain dry-farm areas. In the Cache Valley the first foot of virgin land was found to be 15.9 percent higher in nitrogen and 20.4 percent higher in organic matter than adjacent wheat land. The second- to third-foot section was 14.8 percent higher in nitrogen on virgin land than on cropped land. Losses of nitrogen and organic matter on severely eroded areas in the Cache Valley amounted to 58.5 and 57.8 percent, respectively, as compared with those from level, uneroded land in crops.

The problem of maintaining soil organic matter and nitrogen in the sandy loam soils of the southern Coastal Plain by practical farm practices is of major importance. In this connection, the Georgia Coastal Plain station and the Department (B.P.I.) investigated Norfolk, Tifton, and Greenville sandy loam soils on which varying amounts of vegetation from different crops were grown and returned to the soil to determine the effect of the various systems on the carbon and nitrogen relationships of the soil. Comparisons were made between winter green manure, winter and summer green manure, summer green manure, winter cereal and summer legume, winter cereal and summer legume unfertilized, permanent kudzu, Bermuda grass sod, and cash-crop rotation with summer legumes. Both the organic matter and the total nitrogen of the soil were maintained or increased under all systems. These results indicate that it is not necessary to increase the nitrogen and carbon contents of the soil to high levels to insure production of good crops, but it is important that the green-manuring system followed maintains soil organic matter. The most economical system for using green manure was found to be the one in which the most important cash crop follows the green-manure crop.

In certain agricultural areas where manure is not available and the growing of crops that can be returned to the soil is not practiced, the soil organic matter must be maintained through the use of other organic materials. In view of the potential possibilities of peat in providing this organic material, the New Jersey station suggested that peat should be sold on specifications showing the kind of peat (moss, sedge, and reed, forest peat, and peat soil), its pH value, and its percentage composition with respect to moisture, organic matter, and ash or mineral matter. The vendor of other materials used for adding organic matter to the soil should likewise prepare specifications including the name of the product, its reaction, and its content of moisture, organic matter, and ash.

SOIL MICROBIOLOGY

Problems concerned with the persistence of plant and animal pathogens in soils are closely related to the utilization of infested

soils for crop production. Experiments at the New Jersey station to determine probable causes for the longer persistence of plant pathogens revealed that the soil contained many bacteria, actinomycetes, and fungi which are antagonistic to other micro-organisms and have a highly selective action. Detailed study of a species of soil actinomycetes, known as *Actinomyces antibioticus*, to determine the antagonistic factor led to the isolation of a bacteriostatic substance named actinomycin. This substance was found to have a strong inhibiting effect upon all the fungi and bacteria of the soil. Gram-positive bacteria were inhibited by a dilution of actinomycin in a concentration of 1:10,000,000 or even less, while gram-negative bacteria were inhibited only by a concentration of 1:10,000.

In view of the fact that the character of the soil has a marked effect on the microbiological population present, the Washington station determined, under controlled conditions, the number of bacteria, actinomycetes, fungi, aerobic cellulose-decomposing bacteria, and *Azotobacter* in several different genetic soil types. Certain types supported 19 times as many bacteria, 200 times as many fungi, and 800 times as many actinomycetes as others.

The Utah station reported that nitrogen fixation was increased by *A. chroococcum* when protozoa were present, provided there was sufficient energy material for the bacteria. When food or energy material was omitted, the presence of four coexistent species of protozoa in many cases depressed nitrogen fixation. *Azotobacter* were more numerous in the presence of protozoa than in their absence in both liquid and solid media. It is believed that a substance, perhaps an organic colloid produced by cileates, flagellates, and amoebae, increases the activity of *Azotobacter*.

In a study to determine the presence of *Rhizobium meliloti* bacteriophage in alfalfa fields, the New York (Cornell) station found phage to be present in every field examined and in 58 of 62 samples taken. No correlation was found between age of alfalfa stand, soil type and reaction, and phage presence. From these studies it is concluded that *R. meliloti* bacteriophage is widely distributed in soils used for alfalfa. Under certain conditions, the phage may become sufficiently virulent and concentrated to destroy most of the legume organisms in the soil and thus disturb symbiotic nitrogen fixation, or its presence may be as normal a condition as the existence of the organisms themselves in the soil.

SOIL MOISTURE AND WATER MOVEMENT

Improvements were made in methods of measuring soil moisture under field conditions and in the technique and methods of investigating plant growth under moisture conditions comparable with those existing in the field. The method employing a measure of the electrical resistance of a porous block imbedded in the soil, developed by the Michigan station for obtaining a continuous record of soil moisture, has been found to be especially useful, particularly in connection with irrigation practices.

Determining amount, distribution, and availability of soil moisture by various means has been continued at several stations. For in-

stance, lysimeter studies by the Kansas station are providing information on the day-to-day utilization of moisture by crops as well as a record of amount of moisture lost by evaporation. These investigations will give a better understanding of the critical periods with regard to soil moisture which are likely to occur during the growth of the plant. Knowledge of evaporation may also make it possible to forecast soil-moisture storage from meteorological records.

PHYSICAL PROPERTIES INFLUENCING SOIL TILTH AND CROP RESPONSE

Soil pore space has long been recognized as an important factor in soil aeration and water movement. It now appears in the role of a soil property directly related to crop yield. At the Ohio station, in soils which had become hard, compact, and resistant to tillage after from 40 to 60 years of cultivation (though originally loose and mellow), sugar beets showed an important relation to soil porosity. On plats in which the air capacity ranged from 2.6 to 25.3 percent, yields of the beets ranged in the same order from 1.5 to 18.7 tons per acre.

The state of aggregation or crumbiness and the stability of the soil aggregates are among the more important elements of tilth. A "stability index" and a figure representing "probable permeability" have been calculated at the Pennsylvania station from a combination of the mechanical-analysis data and those obtained in an aggregate determination developed for this purpose. This method has been found valuable in ascertaining the effects of certain cropping practices and treatments upon soil structure.

Cropping systems and soil management exert both direct and indirect influences upon the soil aggregates and aggregation. At the Illinois station plats in continuous corn since 1904 were found poorly aggregated at the surface, but the degree of aggregation increased with the depth. This condition was found not to be due directly to the corn but to a greater degree of erosion under it than under a corn-oats or corn-oats-clover rotation. The B horizon, or second structural layer of the soil, was from 6 to 9 inches nearer the surface under the corn plats than under the rotation plats. Continuous growing either of corn or of wheat at the Virginia station reduced the percentage of soil aggregation as a whole and the separately determined percentage of aggregates more than 1 millimeter in average diameter. The soil of the plat under hay for 30 years was better aggregated than that under the continuous crops. The total percentage of aggregation was the same under a 4-year rotation of corn, wheat, clover, and hay without fertilizer or manuring, but the hay plats had a higher percentage of the larger aggregates. With fertilizer and manure in the same rotation, the clover and hay plat showed higher percentages both of aggregation as a whole and of aggregates larger than 1 millimeter than did the continuously cropped plats.

Micro-organisms may play an important part in the aggregation of a soil and in determining the stability of its aggregate structure. When the New Jersey station treated artificial mixtures of sand with bentonite and with clay, a clay loam soil, and a sandy loam with various organic materials and plant residues, adding pure and mixed cultures of organisms causing decomposition in the soil, a marked

binding and aggregating action upon the soil particles was observed. The more rapid the decomposition of a plant material, the more effective it was in aggregating the finer soil particles. In prairie soils studied at the Kansas station it was shown that soil-particle aggregation is not a direct result of the growth of micro-organisms as such, but is effected by the binding action of byproducts of the bacterial life process.

The condition of the soil colloids influences the physical behavior of a soil with respect to tillage and the growth and health of plants. The New Jersey station has found sources of error in determinations of the degree of dispersion of the soil colloids, and has shown how some of these errors may be avoided. This station has shown also that dispersion determinations have a value as indices of erosion resistance in soils. The bad physical condition of "slick spots," or small areas of alkali soils in which the presence of certain sodium compounds has produced an unfavorable state of the soil colloids, can be corrected advantageously by applications of sulfur, according to the results of the Nebraska station, although this station does not regard this treatment to be at present justified for large areas of alkali soil.

Data from soil-profile studies, such as those from the Federal Soil Survey in which most of the State stations cooperate and from the State soil surveys which are being carried on by several of the stations, are among the foundations of experimental fact upon which sound land use programs must be built.

SOIL CONSERVATION AND LAND USE

Information basic to the establishment of sound economic adjustments in farming practices and cropping systems in the South is being obtained by the Alabama station in studies of the conservation and use in crop production of major elements in fertilizers. Its results indicate that as much as 70 percent of the fertilizers added to light sandy soils in the form of nitrogen may be lost annually by leaching when summer legumes, such as crotalaria, cowpeas, and soybeans, are turned under in the fall. About one-half of this loss was prevented when the legumes were allowed to stand on the land without turning until spring. Much additional conservation of nitrogen resulted when vetch or oats was planted as winter cover crop following fall-turned legumes. Potash losses by leaching were also reduced as much as 85 percent by the growing of winter legumes.

In cooperative studies by the Department (S.C.S.) and the Ohio station to determine soil losses from cultivated strips in strip-cropped fields in the Ohio Valley, soil losses increased with increase in contour divergence, length of watershed above the strip, percentage of watershed above the strip under cultivation, and slope of the strip. Variation in the width of strips under 84 feet did not affect soil losses, and the greatest soil losses were from those strips on which previous erosion had been greatest. More soil was removed from a strip if the watershed above it was clean-cultivated than if it was under a cover of vegetation, and soil losses decreased with increase in the fertility level of a strip. Upon the assumption that a certain soil loss under strip-cropping conditions is permissible, and with this permissible loss as a

basis, critical values were established above which soil losses are deemed excessive. The critical value for contour divergence on residual soils was found to be 5 percent. Good soil-management practices combined with strip cropping were found to be very valuable in reducing soil losses.

Further results on the value of various conservation practices under an average annual rainfall of between 20 and 21 inches were reported from the cooperative studies of the Department (S.C.S.) and the Texas station made at Spur, Tex. Level terraces having ends open were found to be much more efficient in conserving water than terraces with 3-inch slope per 100 feet along the terrace, and to result in an appreciable increase in crop yields. Level terraces with ends so closed as to hold all the water that fell gave an average increase in crop returns for 12 years of $6.21 per acre per year over those obtained by the conventional practice of running the rows with the slope. By diverting the run-off water from a 1,200-acre watershed onto a 120-acre sirup-pan terrace system, the water for use by crops on the system has been increased approximately 16 percent and crop yields have shown a marked increase.

The effect of erosion on crop yields is reported from cooperative studies by the Department (S.C.S.) and the South Carolina station. Using the same rate of fertilizer, the A horizon of Cecil sandy loam was more than three times as productive as the B and 11 times as productive as the C. Organic matter additions in the form of stable manure resulted in increased yields on all horizons, and especially on the C horizon. The unproductive nature of subsoil was also investigated by laboratory and greenhouse tests at the Colorado station, which showed that a lack of available phosphorus and nitrogen in the subsoils accounted for a large part of the decrease in crop yields following loss of the surface soil. An application of 100 to 200 pounds of treble superphosphate with 20 tons of manure per acre was found to give good results in overcoming the unproductive condition of eroded or scraped irrigated lands.

With a view to assisting farmers of southeastern New York in better soil and field-crop management practices, the New York (Cornell) station provided information in bulletin form on climate, general topography, and drainage; the agriculture; the composition and characteristics of the soils of the area; their lime needs; erosion in the area and methods recommended for its control; the production of farm manure; fertilizer experiments and recommendations; rotations and fertilizers for corn and forage crops; special management for gravelly soils; and pastures and forests as a farm crop.

Work on soil survey and land classification according to natural land classes was carried forward by a number of stations. The Utah station drew from reports by farmers the conclusion that soil productivity in the State has declined an average of about 25 percent since the soil was first cultivated. The decline was attributed to the lack of sufficient information on the physical, chemical, and biological properties of the soil to determine the most satisfactory system of land management.

PLANT DISEASES

CONTENTS

As the result of persistent scientific attack, numerous plant diseases that once caused major agricultural disasters or were a continual drain on farm incomes no longer give rise to serious losses or eat away profits. Yet many important plant-disease problems, like many well-known human-disease problems, remain unsolved. The only hope of solution lies in continued scientific study. New plant diseases are also constantly appearing. These must be investigated. Year by year, too, science is adding to the list of chemicals that may be useful in plant protection and seed and soil treatment. These must be tested. Often the best way to deal with a plant-disease hazard is to develop new strains of plants resistant to the infection. In all such work the State experiment stations are active, frequently cooperating with each other and with the Department to promote more rapid and dependable results.

This section of the report is devoted to examples of recent progress by the State experiment stations in the plant-disease field. In emergencies like the present, when the Nation is straining to produce the utmost in needed food supplies, every effort to reduce losses from plant diseases and pests in the field and later in handling and storage is distinctly a contribution to the war effort. In fact, the experiment station job of developing better means of crop protection represents an indispensable element in the "Food for Victory" program.

GRAIN DISEASES

Cereal diseases have probably reduced the income of more North American farmers than any other class of plant diseases. Work on their control, which has long held a major place in experiment station research, has already been of great benefit. In a large part of this work the Department (B.P.I.) has cooperated in a most effective way with the State stations.

Grain smuts.—Much progress has been made in developing grain varieties resistant to the smuts, fungus infections that change the kernels to black powder. This work is not simple for it is necessary to breed for resistance to the numerous existing smut races and to tackle the job again when new smut races arise from time to time, like those which the Washington station found developing from a dwarfing race of bunt (*Tilletia*) when crossed with other races. The North Dakota station learned that Rival, Mercury, and Premier wheats have marked resistance to 20 different collections of bunt. Ceres showed from 0 to 77 percent bunt, but Thatcher was much less susceptible. At the Indiana station hybrids between Hussar-

Hohenheimer and other wheats were found resistant to virulent western races of bunt as well as to Indiana races. The Minnesota station found H–44, Hope, and Thatcher promising as parents for wheat hybrids resistant to loose smut (*Ustilago*), and demonstrated 6 biological races of this smut. Loose smut resistance found in Trumbull, Chinese, and Kanred-Gipsy has been introduced into soft wheats at the Indiana station. Out of 80 wheats tested in 20 years, the Virginia station found 20 resistant to loose smut and high-yielding selections have been made available to growers.

In the oat smuts, 6 biological races were found among 80 collections tested at the Minnesota station. Markton, Navarro, and Nakota were not attacked by any of these races, while Hancock and Marion were slightly attacked by a possibly new smut race. The position of some varieties in the scale of resistance was unfortunately not always the same in different localities or with different lots of seed. Fertilizers had no marked effect on resistance or susceptibility.

Grass smuts, until recently, have aroused little concern. Increasing use of grass, however, for erosion control and to replace tilled crops on marginal land has brought a great demand for grass seed and with it more study at several stations of the diseases that cut down seed and pasture yields. The finding by the Minnesota station of distinct races in smuts attacking various grasses shows that the task of developing smut-resistant grasses is no less complicated than with the cereals.

Grain rusts.—The severe outbreak of stem rust in 1940 proved the value of resistant wheat. Many soft wheats bred up by the Indiana station proved to be both rust-resistant and of excellent type and quality. The Minnesota station with the Department found evidence that in the fall stem rust blows south from the United States into Mexico, survives there, and in winter or early spring blows northward into this country. In 1940 Thatcher wheat held its resistance to stem rust but showed 5 to 15 percent loss from leaf rust. A new, very virulent race of stem rust was found on South American specimens. The North Dakota station found little damage from stem rust on newer resistant wheats. Thus No. 2829 yielded 49.4 bushels and Thatcher 44.4, whereas rust cut the yield of Marquis to 15.2 bushels and of Bluestem (Haynes) to 2.5 bushels. Hence in combined resistance lies the greatest hope for the farmer. The Kansas station obtained resistance to several races of both leaf and stem rusts in 637 out of 1,896 hybrid lines. The Wisconsin station found that reactions to smuts and crown and stem rust of oats are inherited independently in Iowa No. 444 × Bond crosses. Among 5,000 lines of oats being selected at the Arkansas station for resistance to crown rust and smut, a number proved hardy enough to survive the severe freeze of November 1940 and produced considerable winter pasture, outyielding 25 commercial types. The crown rust in Arkansas was found to summer over on volunteer oats and to attack nearby fall-planted oats. In 1938 a severe epidemic gave proof of the value to growers of such rust- and smut-resistant varieties as Boone and Marion, recently released by the Iowa station.

Rice diseases.—The stem rot *Leptosphaeria*, found able to live 7 years or longer in uncultivated rice soil, was best controlled in

Arkansas station tests by the application of 600 pounds of 6–6–12 fertilizer per acre, while ammonium sulfate alone made it worse. Varietal differences in susceptibility were noted. Arkansas Fortuna, Nira, Asahi, and Zenith rice proved resistant to blast, a plague in new rice areas. The Louisiana station multiplied one of its strains of Blue Rose rice that is resistant to *Cercospora* leaf spot. In developing such types difficulties have to be overcome, as at least eight different races of the fungus and several different factors for resistance were found to exist.

Flax diseases.—The Minnesota station, testing some 20 isolates of the wilt *Fusarium* on 6 varieties, found added evidence of an indefinite number of specialized races. Only Pergamino No. 6098, from Argentina, resisted all races tried although it was susceptible to a different *Fusarium*. "Soil sickness" in soil cropped to flax almost continuously for 45 years at the North Dakota station was attributable mainly to the wilt fungus by which susceptible flax varieties were completely invaded. At the same station 24 races of rust were identified and among 201 varieties or strains of flax some proved immune to all North American races though not to all from South America.

COTTON DISEASES

The Department (B.P.I.) continued to cooperate with the State experiment stations in much of their cotton-disease research while the Cotton Disease Council, a voluntary group of workers, promoted exchange of information and teamwork on major problems.

Seed treatment.—Unexpectedly large benefits continued to be realized on treating cottonseed to check seed-borne organisms that cause poor stands and start disease outbreaks. The Georgia station reported an average increase from seed treatment of 178 pounds of seed cotton per acre in tests over 3 years. A new, nonpoisonous, organic dust gave promising results. The South Carolina station noted considerable control of damping-off by *Glomerella* from a sodium hypochlorite treatment, and two new organics gave good results. The Arkansas station found the benefits from cottonseed treatment greater where rainfall was excessive. Probably over 75 percent of the Arkansas cotton acreage was planted with treated cottonseed in 1941. The Mississippi station found two new organics promising. The best treatments tested for 5 to 8 years in over 150 trials gave an average return of more than $8 per acre. Acid delinting did not appear practicable or profitable under prevailing Mississippi conditions.

Cotton anthracnose and angular leaf spot.—Surveys conducted jointly by 13 experiment stations and the Department (B.P.I.) showed cotton anthracnose (*Glomerella*) to be present as a boll rot in over 90 percent of the fields in 11 States, although doing but little damage west of the Mississippi. The South Carolina station developed a rapid laboratory method to test cotton for resistance to anthracnose injury, and showed that bacterial leaf spot germs were often present on affected foliage, apparently paving the way for more damaging anthracnose infections. The Arizona station reported an unusual case of dust dissemination of the bacteria of angular leaf spot during a local cyclonic storm. A loss of some $30,000 resulted from the severe infection that followed.

Cotton wilt.—In a cooperative study at the Louisiana station of cotton resistance to *Fusarium* wilt, the most resistant variety showed less than 0.5 percent of wilt as compared with 87 percent in a common susceptible variety. Seed stocks of some of the best lines were made available to growers. In tests of many hybrid and inbred cotton lines at the North Carolina station a few showed no wilt infection and numerous selections were made. Work at the South Carolina station indicated that wilt Fusaria from cotton, tobacco, okra, coffeeweed, and probably other plants should perhaps be looked upon as one variable species. This may prove important in planning crop rotations. The Alabama station found wilt worse where cotton followed okra, sweetpotatoes, cowpeas, or susceptible cotton. Regional tests have disclosed the best wilt-resistant varieties for several States. The Texas station found, as in other States, that potash will reduce damage from wilt and "rust" (potash hunger) in east Texas sandy soils, giving average yield increases of 28 to 38 percent with 24 pounds per acre. The Arkansas and Alabama stations with the Department (B.P.I.) found, however, that acid phosphate applied to potash-deficient soils may aggravate both the "rust" and wilt. The Arkansas station found the newer Arkansas Rowden strains wilt resistant enough for most conditions in the State.

TOBACCO DISEASES

Leaf spot diseases.—The leaf spots are highly erratic but extremely destructive when conditions permit. The Kentucky station showed bacterial blackfire to be serious in places where soil is deficient in phosphorus and potash if wind can spread the germs while the leaves are wet with rain and the leaf pores are open. Bordeaux spray on the plant beds, rotation with at least 2 years of grass-legume mixture, and heavy manuring and fertilizing gave large yields of relatively disease-free, high-quality leaves. Both green spot on cured burley and "frogeye" in the field were found to be due to infections by *Cercospora.* The Pennsylvania station found that plants free from disease when set out showed less wildfire at maturity than those carrying infection when planted.

Black root rot.—The Tennessee, North Carolina, and Georgia Coastal Plain stations cooperating with the Department (B.P.I.) got best results in the control of black root rot (*Thielavia*), root knot eelworms, and weeds in tobacco plant beds by a combination of cyanamide and chloropicrin. The Virginia station found organic matter ineffective against root rot, but cyanamide or urea treatment of the beds in the fall proved as effective as steam treatment. A high-yielding, root rot-resistant strain of bright tobacco discovered by this station was under test for quality. The West Virginia station found no root rot-resistant strains superior in yield or quality on infested soil to the Kentucky station variety, Kentucky No. 16.

SUGAR-PLANT DISEASES

Sugarcane diseases.—As a supplement to the existing program of breeding by the Puerto Rico University station, several cane varieties

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used in differentiating the known types of viruses were secured from the Department (B.P.I.). Based on the symptoms produced in these "index" varieties, a number of types or strains of the mosaic virus have already been isolated and propagated from spontaneous infection in 17 varieties of sugarcane growing in Puerto Rico. Yield tests by the Louisiana station have continued to show rather heavy losses from infection by mosaic and the fungus red rot, and the value of using mosaic-free seed cane of susceptible varieties was strongly emphasized by the results obtained. Variations in the parasitism of races of the fungus causing red rot were also demonstrated, a fact of importance in the development of resistant varieties.

Sugar beet diseases.—Analyses of both field- and greenhouse-grown sugar beet plants by the Iowa station indicated that the *Cercospora* leaf spot or blight materially reduces the percentage of sucrose in the crowns, roots, leaves, and leaf stalks, and that the total nitrogen in the leaves decreases with the severity of infection. Furthermore, as the leaves become more severely affected their ability to assimilate carbon dioxide in the photosynthetic process diminishes. The general conclusion from two seasons' tests of copper-lime dusts and bordeaux mixture by the Ohio station is that it pays to spray or dust sugar beets for the control of this blight, dusting as a whole giving slightly higher yields than spraying.

In an investigation of the cause and control of heart rot of sugar beets, the Michigan station found that borax prevented the development of the trouble, practically doubled yields, and increased the sucrose content of the roots, whereas copper, manganese, or magnesium neither prevented the disease nor affected the sucrose content. The Washington station reported that growers were using borax consistently and with success in that State to control crown rot in sugar beets.

FORAGE AND COVER-CROP DISEASES

A new race of smut discovered on wheatgrass and wild-rye was found by the Washington station and the Department (B.P.I.) highly infectious also for squirreltail and barley grass, bringing to 43 the grand total of known susceptible grasses in the United States. Six collections of slender wheatgrass appeared to be resistant or immune. After 8 years' experiments with collections of head smut from 36 species of grasses, the presence of 8 distinct physiological races has been established.

A thinning-out of Metropolitan bentgrass during hot weather has recently been traced by the Pennsylvania station to fungus invasion (*Helminthosporium* or *Curvularia*) as has the sudden disappearance of annual bluegrass, spoken of as "going out" or "melting out." Among the control methods tested small applications of dusting sulfur or zinc oxide were the most promising. Field data indicated certain selected strains of redtop to be resistant.

Alfalfa yellows.—This boron-deficiency disease is reported by the Connecticut (Storrs) station to have been prevalent on one of the best agricultural soils of the State. The disease was cured by addition of borax at the rate of 20 pounds per acre.

Austrian Winter pea diseases.—The Georgia station, cooperating with the Department (B.P.I.), by using electrically heated and controlled hotbeds covered with heavy cloth tested garden peas for

resistance to fungus blights during the winter and spring months. By this method two crops of seed a year were grown and severe epidemics of the diseases could be produced for testing varieties and selections.

Peanut diseases.—Rot diseases of the peanut were reported by the North Carolina station to cause considerable annual loss. Many common soil-borne parasites attack the underground parts but tests showed that it depends largely on previous cropping, which parasite is the main cause, and how severe the rot is. Heavy applications of fungicides to the soil surface have given some control for stem and nut decay. This station has also shown that 2 weeks' spacing between applications of sulfur dust gives better control of *Cercospora* leaf spots than wider intervals. In recent tests, various copper and sulfur sprays and dusts increased the yields by 408 to 1,000 pounds per acre. At the Virginia station, dusting 3 times with very fine sulfur reduced *Cercospora* leaf infection enough to prevent excessive leaf shedding. Furthermore, harvesting could be delayed from 5 to 10 days without serious loss of nuts.

POTATO AND SWEETPOTATO DISEASES

Bacterial ring rot.—This destructive infection has swept rapidly through the country since its first entrance. The potato industry, however, has reason to hope that the disease will never grow into a major calamity. Rapid application of preventive practices, worked out by coordinated station and Department (B.P.I.) research, gives promise of holding losses down permanently to a low figure. Field tests at the California station, as elsewhere, showed the necessity of avoiding spread by the unsterilized seed-cutting knife and picker planter. Neither this station nor the Idaho station had as yet found a chemical that completely eliminated infection from seed contaminated in cutting. Fortunately, no station has yet found any evidence of field survival in the soil from one season to the next. The Idaho and Utah stations found no indication of field spread by irrigation water, but the Colorado station found evidences of spread in irrigated fields by some other agency, flea beetles being suspected. The Montana station found that above 40° F. ultraviolet light is not so effective in detecting ring rot. For destroying the germs on cutting knives this station found that calcium hypochlorite may replace mercurial dips. The North Dakota station learned that although grasshoppers feeding on potatoes may swallow ring rot bacteria, they probably do not spread infection. The Maine station found several potato-seedling varieties apparently resistant to ring rot. Both acid mercuric chloride and sodium hypochlorite worked well against contamination, as was demonstrated also by the West Virginia and other stations.

Late blight.—Potato growers are a year nearer a permanent solution of the potato late blight (*Phytophthora*) problem. The New York (Cornell) station tested about 25,000 new seedlings during the year. About half proved to be immune to this blight. Three selected earlier were ready for adaptability trials, and one survived the severe outbreak of 1940 without a trace of blight. The Maine station and the Department (B.P.I.) found that certain seedlings

from self-pollinated Katahdin had both foliage and tuber resistance. The New York (Cornell) station got indications that accumulation in the soil of copper from spraying year after year may help prevent tuber infection. The Maine station found none of the "insoluble" copper fungicides tested to be superior to bordeaux against either late or early blight (*Alternaria*).

Scab and Rhizoctonia.—These two diseases are probably the most important soil-borne potato infections. Better methods of seed treatment are sought to stop their carry-over on the seed tubers. The Maine station confirmed the value of acetic and hydrochloric acids in shortening treatment and keeping up the strength of mercuric chloride solutions. The Minnesota station finding that races of the scab organism *Actinomyces* differ in ability to grow at different acidity levels may explain the variable success of efforts to control scab by acidifying the soil.

Several State stations and the Department (B.P.I.) have continued working to get scab-resistant potato strains. The Indiana, Michigan, Nebraska, Wisconsin, and Wyoming stations reported a number of such selections. The Minnesota station found that scab resistance may vary in some lines from year to year and from place to place. In 1940 the Wisconsin station had 18,000 new seedlings under scab test and the New York (Cornell) station about 7,000.

Virus diseases.—Year-in and year-out virus diseases probably cause the largest losses to the potato industry. The New Hampshire station found the symptoms of mosaic indistinct in plants growing at around 68° F., but easily detected at 58°. Leaf-roll symptoms, however, were not affected by temperature. The Maine station found that while virus damage depended in part on the variety, in general leaf roll and spindle tuber caused more loss than rugose mosaic but the latter caused more than mild mosaic. Leaf roll spread fastest in southwestern Maine, whereas mild mosaic spread fastest in northeastern Maine and caused the most loss there. Spread was least in well-isolated seed plats where early roguing had removed infection sources. The same station showed how to distinguish leaf-roll net-necrosis in tubers from noninfectious stem-end browning. Of 100 common weeds tested, the New York (Cornell) station found 12 capable of carrying the serious potato yellow dwarf virus.

Root knot nematode.—In Oregon these microscopic eelworms caused some $100,000 loss to one year's potato crop and equal loss to other crops. Wheat, barley, and rye were the best rotation grains to reduce attack on potato in the worst area, but the most effective control was obtained by the Oregon station and the Department (B.P.I.) from summer fallowing.

Sweetpotato wilt.—The Delaware station found that by treatment of the roots with mercurials or copper oxide sweetpotato stands were increased from 10 to 60 percent in normal years through control of *Fusarium* wilt, also known as "yellows" or "split stem." This disease has caused losses of from 5 to 60 percent in the Jersey type of sweetpotato.

Soil rot or pox.—The Louisiana station found that adding enough sulfur to make the soil as acid as pH 5 gave very effective control of the soil-borne pox fungus, newly described as *Actinomyces ipomoea*. Although very like the closely related potato scab fungus, it does not

attack white potatoes and vice versa. Soil rot has spread seriously into most of the commercial sweetpotato areas of Louisiana, causing abandonment of this crop on a number of farms. The New Jersey station found that although sulfur will control pox, it makes it hard to grow ordinary vegetables after sweetpotatoes.

Soft rot.—In the winter of 1940–41 there were enormous losses from *Rhizopus* soft rot. Perhaps 50 percent of the New Jersey sweetpotatoes removed from storage were destroyed. The New Jersey station found, however, that dipping the roots in a cheap borax solution as they are taken out will almost eliminate rot and also improve the color.

TRUCK-CROP DISEASES

Bean diseases.—An apparently new virus disease of bunch and pole snap beans and lima beans, studied by the Georgia station and designated "black root," was found transmissible by infected juice and also through the seed.

The Nebraska station has developed bean crosses with high physiological resistance to bacterial halo blight and a few crosses very resistant to the common bacterial blight. Wide variation was found among strains of the halo blight bacteria, both in their virulence and in the type of symptoms induced. The Louisiana station found seed treatment helpful against these blights but California-grown seed without treatment produced plantings free from either.

Virginia station tests of some 135 hybrid strains and selections of beans developed by the Virginia, Alabama, and Florida stations and the Department (B.P.I.) showed many to be vigorous, extremely productive, of fine quality, and highly resistant to one or more strains of bean rust. Progeny tests of almost a thousand Georgia station crosses of snap beans gave promise that high quality root rot- and nematode-resistant strains adapted to Georgia conditions can eventually be obtained. From its breeding work with the Alabama No. 1 bean, the Alabama station has concluded that resistance to the root knot nematode is inherited as a double recessive trait, probably on a quantitative basis.

Pea diseases.—From a study by the New York State station of 163 commercial varieties and strains of peas, it is apparent that there is no strain that is commercially resistant to the root rot complex existent in the State. Field surveys and cultures indicated two fungi (*Fusarium solani* var. *martii* and *Aphanomyces euteiches*) to have been the most prevalent and destructive root rot organisms in 1940, the *Fusarium* apparently being the more important. Several compounds were capable of preventing seed decay, but outstanding was the discovery that a new hydro-quinone compound—a development from the rubber industry—effectively protected the seeds without injury to any variety tested and encouraged larger yields than the usual fungicides. The Minnesota station reported field tests in which this material gave a maximum increase of 800 pounds of green peas per acre.

Cantaloup wilt.—A form of the destructive *Fusarium* wilt recently made its appearance in Minnesota, becoming a menace to successful growing of cantaloups on the warmer sandy soils where they had been the most profitable crop. As a result of a breeding and selection pro-

gram by the Minnesota station and the Department (B.P.I.), the wilt-resistant variety Golden Gopher has been introduced.

Watermelon rot.—A decay of Winter Queen watermelons on the New York City market was found by the Missouri station, cooperating with the Department (B.P.I.), to be due to *Phytophthora capsici*, a fungus originally described as the cause of pepper blight. This fungus proved to be pathogenic also to a variety of fruit and garden crops, and to be arrested by transit temperatures of 45° to 50° F.

Scab of cucumbers.—In addition to testing cucumber varieties for resistance to the fungus (*Cladosporium*) scab disease, the Maine station has placed one of its resistant selections (Maine No. 2) in limited use by growers, where it has appeared satisfactory for home-garden planting.

Onion yellow dwarf.—Transmission tests with this virus by the Iowa station were successful with 48 species of aphids, but not with any other insects tried. Over 30 onion varieties were found susceptible to the disease. A large number of other plant species failed to take it. Control may be accomplished by destroying left-over bulbs in the field and use of disease-free sets.

Clubroot.—In studying the effects of sulfur, nitrogen, and potassium in nutrient solutions on the development of clubroot (*Plasmodiophora*) in susceptible and resistant members of the cabbage family, the Wisconsin station has thrown light on the factors responsible for the disease symptoms. In New Jersey station tests, clubroot was controlled by adjusting the soil reaction to pH 7.3 or over with calcium, magnesium, sodium, or potassium compounds. The Wisconsin station and the Department (B.P.I.) also studied clubroot resistance in varieties of rutabaga and turnip in the United States. The results, together with previous findings here and in Europe, indicate that the pathogen probably consists of more than one physiologic race.

Celery diseases.—A serious storage rot of late celery, causing losses in 5 counties in western New York, was traced by the New York (Cornell) station to a fungus (*Cercospora cari*) described in 1924 as causing a disease of caraway. The name "greenish black rot" is suggested to distinguish it from *Phoma* rot, with which it may easily be confused. None of the 12 commercial varieties tested proved markedly resistant.

The Florida station found that over 90 percent of the fungus sclerotial bodies which carry over the celery pink rot disease could be destroyed by flooding muckland for 6 to 8 weeks in summer. Of various chemicals applied to the soil, only calcium cyanamide destroyed the sclerotia.

Losses from *Fusarium* yellows of celery are reported by the Ohio station to have been increasing in that State. In tests of 71 varieties, selections, and hybrids, 6 green varieties and certain self-blanching sorts proved resistant.

Tomato diseases.—The tomato industry of Utah, valued annually at between 2 and 3 million dollars, involves some 1,500 growers. The curly top disease, transmitted by the beet leafhopper, seriously reduces yields in years when the insects are abundant. Through the finding that serious losses may be prevented by a double-hill system of planting, the Utah station, cooperating with the Department (B.P.I. and B.E. and P.Q.), has made important progress toward a practical solu-

tion of this problem. In 1940, a year of heavy infestation, when there was a two-thirds loss in yield from single plantings, double plantings gave about normal yields.

New Improved Ceresan gave good control of early blight (*Alternaria*) at the Georgia station without apparent injury to seedlings except after long seed storage. Without recourse to seed treatments, seed-borne infection was controlled by storing the seed until the second year after harvesting.

Resistance to tomato wilt received attention by various experiment stations. The Missouri station continued developing wilt-resistant tomato varieties by use of a strong genetic factor for resistance secured from a strain of cherry tomato. The Tennessee station reported that a number of wilt-resistant selections and certain segregates of crosses made a good showing. The Riverside tomato, developed by the California station and the Department (B.P.I.), has proved highly resistant to both *Fusarium* and *Verticillium* wilts. The Utah station reported promising results in breeding for resistance to both *Verticillium* wilt and bacterial canker. The Texas station made progress in selecting and developing wilt-resistant tomatoes and in wilt, root knot, and damping-off prevention by soil injection of chloropicrin. Control of soil organisms by chloropicrin in Rhode Island station tests resulted in field trial increases from almost 5 tons to more than 17 tons per acre of first-quality tomatoes.

The Wisconsin station found that tomatoes are easily infected by the dangerous bacterial ring rot of potato, an apparently recent introduction. Planting infected seed yielded diseased seedlings. Perhaps the tomato may sometimes serve as an important agent in harboring and transmitting ring rot.

Sweet corn bacterial wilt.—Iowana, a wilt-resistant golden hybrid sweet corn developed by the Iowa station, has consistently outyielded ordinary Golden Bantam from 60 to 80 percent, often actually doubling the weight of ears per acre. In the last 3 years it has set similar yield records as far east as Maryland. This hybrid is resistant to bacterial wilt (*Phytomonas*), a disease frequently causing extreme damage to Golden Bantam and other susceptible varieties, and it is also resistant to smut. The new variety can be grown from coast to coast in the northern part of the United States, and has been grown successfully in some of the Southern States.

Root knot nematode.—This almost microscopic nematode worm is undoubtedly the most destructive animal pest of truck and farm crops in Florida, causing losses of several million dollars annually. Various trees and ornamentals are likewise subject to injury. The Florida station has made a study of the host plants, including their degree of infestation and the severity of the damage sustained. An exhaustive survey of watermelon and tobacco fields appeared to indicate the desirability of a 2-year rotation with fallow in alternate years. Cyanamide gave considerable relief, but more by aiding plants to overcome the effects than by actually killing the nematodes. Root knot was eliminated in a single summer by growing on the land a cover crop absolutely immune to it, with destruction of all other plants. A resistant strain of Big Boston lettuce has been developed by the station, and a strain of markedly resistant Conch cowpeas has been discovered, selected, and distributed. The system of mulching in-

fested soil heavily gave promise of greatly aiding the growth of such susceptible perennials as figs, roses, papayas, etc.

ORCHARD DISEASES

Apple scab.—Apple scab continues to be a major problem for apple growers and still receives major attention by stations in apple-growing States. A recent speeding up of study on the usefulness and limitations of eradicant ground-spraying methods has resulted from voluntary teamwork by investigators in a number of States under a leader at the Wisconsin station. Among the eradicants tested further were sodium dinitro-orthocresylate and monocalcium arsenite. Reports received from the Wisconsin, New York State, New Jersey, Delaware, Minnesota, Illinois, and Indiana stations indicate that eradicant sprays are of particular value with a heavy carry-over of the apple scab fungus in the old leaves. A late-dormant ground spray then insures better fruit protection from later scab sprays and permits the use of milder and less injurious materials in these applications.

Internal cork of apple.—In experiments covering 14 years the New York (Cornell) station proved that apple "cork" is the result of boron deficiency and showed that it can be prevented, even in dry years, by fine granular borax applied in a ring beneath the tips of the branches in early spring. A bulletin summarizes the knowledge developed in this research. The same station discovered that water-logged soil may give fruit effects like those of boron deficiency. The California station found that sometimes boron and sometimes potash gave improvement from a type of dieback, accompanied by rough bark and at times cork of the fruit, found on apple trees occurring in an acid, infertile soil.

Apple cankers and wood decay.—The Minnesota station found most apple trees 30 years old or over badly affected by decay, leading, doubtless, to early decline. Ten recognized wood-rotting fungi and probably as many unidentified ones were involved. Proper prevention and care of wounds is held likely to increase the bearing life of such trees.

Pear fruit rot.—The Washington station found 75 species or strains of fungi involved in the decay of pears. Over half of the rot was produced by blue mold (*Penicillium*). Gray mold (*Botrytis*) rot, next in importance, was kept from spreading nearly as well by the Caronite as by the Hartman fruit wrap.

Bacterial leaf spot of peach.—Bacterial spot was found by the North Carolina station to respond in sandy soils to nitrate of soda applied every 2 weeks after the July harvest. The peach foliage remained green until frost with only slight infection.

Cherry leaf spot.—This disease, caused by the fungus *Coccomyces*, is a major cause of leaf drop and low yields. In a 5-year test by the New York (Cornell) station, foliage injury on Montmorency cherries was greater, the fruit smaller, and yields lower with lime-sulfur or bordeaux used against it than with flotation sulfur or copper oxychloride. Bordeaux and copper oxychloride checked leaf drop better than the other sprays. The Michigan station found cupro K superior to bordeaux or lime-sulfur from the standpoint of foliage in sour cherries. The Ohio station, in 3 years' tests, found fixed copper sprays to give good control with little injury on sweet or sour cherries or plums. The New Jersey station found copper fungicides more effective than sulfur,

home-made copper phosphate being very satisfactory. The Wisconsin station 3-spray program of bordeaux 6–8–100 gave as good results as any modified programs or substitute sprays tested. The Oregon station, in testing 117 combinations of sprays, found lime-sulfur with lead arsenate to give excellent control of both cherry leaf spot and cherry fruit fly. The West Virginia station, however, found fixed copper sprays much superior to lime-sulfur in leaf spot control under local conditions.

Virus diseases of stone fruits.—Continued research in several States often aided by the Department (B.P.I.), disclosed further facts bearing on this complex group of diseases. The Colorado station found three, possibly four, different strains of peach mosaic. The California station likewise found mosaic strains, some of which attack certain varieties without producing symptoms, and also discovered strains of a virus group, tentatively called peach ringspot, as well as apricot-almond mosaics of wide local occurrence. The ability to distinguish these viruses has greatly helped the agencies that are eradicating peach mosaic.

The "X-disease" or yellow-red virosis of peach and eastern chokecherry, first described from Connecticut, was reported by the Maryland station as extending into Maryland. According to the New York State and (Cornell) stations this disease is a serious threat to peach growing in the State. Spread can be prevented by destroying chokecherries within 500 feet of peach trees. A single application of sodium chlorate in early summer is effective. The Utah station reported a virus resembling but apparently not identical with the X-disease of the East which seemed to spread freely from peach to peach. The California station reported a leaf-casting yellows of peach in several counties, similar to the X-disease and apparently caused by the same virus as the buckskin disease of sweet cherry. The Oregon station found peaches and chokecherries in eastern Oregon affected by what is apparently the same disease. The Wisconsin station found a leaf-yellowing virus transmissible from sour cherry to sour cherry and to chokecherry, but it remained to be learned whether this is related to the X-virus. The Oregon station reported a virus that causes a clearing of leaf veins on black sweet cherries with lowering of yields and fruit quality. A virus causing roughened bark, leaf distortion, and severe dwarfing was also found in Oregon on flowering cherry (*Prunus serrulata*). Studies have been started to get facts that will help in devising methods of control.

Melanose of citrus.—Florida station studies over nearly 10 years showed that this important fungus disease (*Diaporthe*) may usually be checked by using 6–6–100 bordeaux 2 or 3 weeks after normal bloom. Several "insoluble" copper fungicides proved nearly as good. Addition of wettable sulfurs helped to kill mites and scale "crawlers." Pruning out dead wood was also beneficial.

SMALL-FRUIT DISEASES

Grape diseases.—The Georgia station has studied the life cycles of fungi attacking muscadine grapes, viz *Guignardia* (black rot), *Mycosphaerella* (angular leaf spot), *Macrophoma* (soft rot), and *Melanconium* (bitter rot). As a result a shorter, more economical, yet effective

spray schedule was developed in which a dormant spray is followed by a few applications of bordeaux. In a search for a grape rootstock resistant to root rot, the Georgia station found the Dog Ridge stock producing the highest vigor and greatest yields thus far, although Warren and Constante appeared promising. In limy soils of the Rocky Mountain area enough iron is often not available and plants develop chlorosis and do not thrive. The Utah station proved that if certain European (*vinifera*) grapes like Tokay, Muscat, Malaga, or Rose of Peru are used as rootstocks, Concord grapes can be grown successfully without chlorosis in such soils. Only temporary correction of chlorosis was produced by injections or sprays with iron salts.

Root diseases of strawberry.—The soil-borne red stele (*Phytophthora*) infection is spreading in the United States. The Tennessee station reported its start in that State from an outside shipment, and its presence on the Pacific coast was noted by the Oregon and California stations. Breeding for resistance is making good progress in several States, the work being in part cooperative with the Department (B.P.I.). The Minnesota station confirmed the fact that the soil-borne fungus *Rhizoctonia* is one cause of root rot. The Tennessee station reported that two fungi, *Hainesia* and *Coniothyrium*, were commonly associated with blackroot and that final tests were being given three promising strawberry hybrids resistant to root trouble.

Strawberry virus diseases.—The Washington station reported crinkle and yellows as among the chief causes of "running-out" of strawberries in western Washington. Greenhouse methods were being employed to develop a stock of the Marshall variety free from such diseases. The Oregon station discovered a new virus disease called "stunt" present in western Oregon and Washington. It is transmitted by aphids and may occur in the same plant with the crinkle virus.

Leaf diseases of strawberry.—A chlorosis or leaf yellowing in the Progressive Everbearing variety appears to be an inheritable abnormality, in the light of Montana station findings. Seedlings free from the disorder were being propagated in the hope of establishing a healthy strain. The Louisiana station discovered an undescribed species of *Mycosphaerella* causing a leaf spot. It found no better material than bordeaux for the control of this and other leaf spots. A promising leaf spot-resistant variety, Klonmore, developed by the station had been released to growers. If varieties like this, requiring no leaf spot spray, should replace susceptible varieties Louisiana growers would save perhaps $100,000 a year.

Raspberry diseases.—In studying a root disease affecting perhaps 65 percent of the Cuthbert raspberries in the State, the Oregon station found a fungus in the roots. Irrigation appeared to make the disease worse. Youngberry, Boysenberry, and Loganberry also seemed to be subject to it. The Department (B.P.I.) was helping in a resistance test of varieties. Methods of chemical eradication that gave promise in the station laboratory were being tried out in the field. The station obtained evidence that "crumbly berry" or "jumbo hill" of Cuthbert red raspberry in Oregon may be of virus origin. Selection against it had been successful in several plantings. Resistance tests by the Washington station in the Spokane Valley revealed no raspberry mosaic infection, after 3 years' exposure, in Newburgh, Taylor, Marcy, or Indian Summer. At the Minnesota station, a delayed-dormant 0.5-

percent Elgetol eradicant spray promisingly reduced infection from raspberry anthracnose, a disease that had caused up to 50 percent crop loss.

Other small-fruit diseases.—The Oregon station obtained satisfactory commercial control of blackberry leaf spot (*Mycosphaerella*) with winter-strength lime-sulfur in March. At the same station dwarf, a destructive disease of Loganberry and Phenomenal berry, was found transmissible also to Youngberries and Boysenberries, but fortunately these appeared resistant or tolerant to the virus. The New Jersey station reported preliminary success in control of the double-bloom, fungus disease (*Cercosporella*) in dewberries by a simple bud-roguing method.

ORNAMENTAL-PLANT DISEASES

Diseases of bulbous ornamentals.—In an attempt to determine and control the viruses infecting lilies, the Oregon station found that combining inoculations between lilies and tulips with microscopical examination of the results has materially advanced the knowledge of the viruses concerned and greatly facilitated the detection of their presence and differentiation. A species of lily has been proved usable for breeding against virus infection, and studies of the decline disease of narcissus have furnished information which will materially aid in the control of this disease also.

Carnation diseases.—The Washington station has found that two viruses are associated with the yellows disease, one readily transmitted by mechanical means and the other transferred only through the agency of aphids. Low nitrogen, phosphorus, or potash availability increased the severity of the symptoms.

Two-year tests by the Pennsylvania station in a commercial greenhouse indicated that certain growth-promoting substances materially reduce the incidence of *Alternaria* blight or branch rot over the potassum permanganate soak method. The incidence of infection in some cases is reduced to about 8 percent as compared with over 80 percent for the untreated cuttings.

Geranium leaf curl and mosaic.—These two important virus diseases of geraniums in the greenhouses of the State were found by the Washington station to be readily transmitted by grafting, but not by the seed or by any insects or mechanical means tested. Applications of manure water and, to a lesser extent, use of Vigoro or iron sulfate around severely affected plants caused them to outgrow the leaf curl symptoms, and nearly complete control was obtained by carefully roguing from a bed of stock remaining in the greenhouse for 3 years and making all cuttings from the rogued bed.

Virus diseases of cineraria.—Studies by the Washington station of the virus-induced mosaic and streak diseases have shown that both viruses are carried over in the seed. Seed produced on virus-free plants given to three growers produced stock remaining healthy during the growing season and materially reduced the losses ordinarily encountered in the greenhouses. A large quantity of seed has been collected from virus-free plants for further production of healthy stock.

Rose diseases.—In continuation of its studies of powdery mildew, experiments under glass by the New York (Cornell) station have

shown that addition of certain wetting agents to spray solutions often increases their effectiveness under severe mildew conditions. Two factors, degree of wetting and toxicity, have been found responsible for the differences among sprays containing different wetting agents.

TREE DISEASES

Rust of red cedar and apple trees.—The cedar rust disease of apples has for many years been a significant limiting factor in orchard production in the Eastern Panhandle of West Virginia, and many cedars of value as windbreaks or as ornamentals have been removed to secure protection for apple orchards. The West Virginia station, during a long investigation of the rust fungi that attack apples and red cedars, found a red cedar seedling which proved to have high resistance under 15 years' tests and observations. This seedling has been propagated and distributed to other sections of the country. In experiments by the Michigan station a single spray application of 1 percent dinitrocresylate (Elgetol) to rust galls or injuries on red cedar and dwarf juniper, when the spring spore masses (telia) had started to develop, stopped further development and prevented germination of the disease-carrying spores.

Chlorosis of pin oaks.—Complete cure of this deficiency disease was obtained within 3 months after injecting ferric phosphate into the trunks at the rate of 5 grams per inch of trunk diameter, according to a report by the New Jersey station. Trees receiving a mixture of powdered sulfur, aluminum sulfate, and ferrous sulfate, placed in holes around them, showed considerable improvement in leaf color and twig growth over untreated trees but were less healthy than those receiving the trunk injections.

Bleeding canker of hardwoods.—The discovery by the Rhode Island station of beech, elm, and at least two species of oak trees infected with this fungus (*Phytophthora cactorum*) disease, previously observed only on maples, has very materially increased its importance. Trees with confirmed infection were found at various points in New England, on Long Island (N. Y.), and in California. A method of successful internal medication for checking injury caused by this parasite of the sap-conducting elements was found in the use of "Helione orange" (a proprietary dye plus a penetrant), which proved capable of inhibiting the growth of this and other pathogenic fungi and of inactivating the toxins formed by them.

Miscellaneous diseases of hardwoods.—A sudden epidemic of foliage blight on 6-month-old mahogany (*Swietenia*) trees was ascribed by the Puerto Rico University station to a new species of the leaf-infecting *Phyllosticta* group of fungi.

FUNGICIDES

Recent advances in chemistry are resulting in the continued improvement of the older fungicides and in the development of new materials for plant protection and seed and soil disinfection. The aim is to get types that will be safer, more effective, more economical, and easier to use. Station progress in this direction is presented largely in the foregoing sections, but attention is drawn to some of the results not referred to elsewhere.

A chlorinated organic.—A new type of chlorinated organic compound developed in the rubber industry was found by the New York State station to be very effective and entirely safe for seed treatment with all varieties of canning peas tested, whereas standard red copper oxide injured some varieties. At least five "insoluble" copper compounds were also proved to be effective seed protectants. Several were much less expensive than standard red copper oxide.

Pentabasic copper oxychloride-sulfate.—The New York State station discovered this new material to be of distinct promise. In preventing tomato-leaf blight without injury it found this type of copper spray about as effective as cuprous oxide. It was learned that bordeaux could also be used with little injury by reducing the lime content and increasing the dilution. Profits from using two of the newer safe materials on tomatoes in these tests ranged from $25 to $54 per acre.

Fungicidal bacteria.—The California station discovered that *Bacillus vulgatus* and another species of soil bacteria can destroy a number of organisms that cause plant and animal diseases. This adds to the list of germs that may serve agriculture in one way or another. It remains to devise practical ways whereby such bacteria or their products can be used in disease control.

Silver compounds.—The New York (Cornell) station in a study of over 70 silver preparations found three mixtures especially promising as plant sprays, comparing favorably with bordeaux but leaving no unsightly residue. The most adhesive was a mixture of silver nitrate, hydrated lime, and ferrous sulfate. Silver sprays gave excellent control of *Botrytis* blight of tulips and may have possibilities as seed or soil disinfectants.

Volatile fungicides.—Principles involved in the use as fungicides of such compounds as benzol and paradichlorobenzene were worked out by the Virginia station with Duke University. They take into consideration not only the plant and the fungus but also the temperature and other environal factors. The results of the study should be of wide practical application.

Tear gas (chloropicrin).—The value of chloropicrin as a soil disinfectant against weeds, wilt, rot, and plant nematodes, as brought out by other stations, was confirmed by the New York (Cornell) station, which demonstrated that for sufficiently valuable outdoor crops the expense is warranted. By injecting a piece of infested ground the production of cut carnations was doubled.

Compatibility.—Fungicides and insecticides should not be combined if the activity of either is thereby reduced or danger of plant injury is increased. The Delaware station brought out the incompatibility of supposedly inert spray ingredients. Eighty-one so-called inert substances were mixed with cuprous oxide and calcium arsenate. After dilution with water, determination was made of the amount of toxic copper and arsenic set free. Depending on the material added, the free copper released varied from 0 to over 70 parts per million and free arsenic from less than 30 to over 800 parts. The Rhode Island station learned that certain materials added to sprays may make them fungicidally useless. Thus the importance of pretesting any proposed new spray combination is evident.

ECONOMIC ENTOMOLOGY

CONTENTS

With the new demands for food from this country, the insects' toll of the various crops takes on humanitarian as well as financial significance. Research entomologists in the stations and Department during the last year emphasized work on stored-grain pests, for insect damage there directly affects food supplies for the Army or for shipment to other countries. They continued varietal resistance studies, investigated ecological influences contributing to insect damage and the influence of crop associations and cultural practices contributing to insect control, developed new insecticides and insecticide combinations, and discovered how former insecticides might be used more efficiently. Progress was made toward the development of more effective bee culture. Much remains to be done in their war on insect pests, but the following examples illustrate the progress made by stations (often in cooperation with the Department) on both old and new insect problems.

CEREAL AND FORAGE INSECTS

Stored-grain insects.—Development of the Ever-Normal-Granary Program on a national scale and the consequent general increase of grain stored on farms have created new demands on experiment station and Department entomologists for practical methods for stored-grain insect control. The control for a given situation must take into account such factors as the type of storage unit, weather conditions, and kind of grain, and whether the particular grain is bagged or loose in bins, and, as a background for any control practice, an intimate knowledge of the biological habits of the particular insect involved is essential.

The Mississippi station, as part of its contribution to this subject, constructed an experimental crib and developed methods for rearing corn weevils under known conditions. Preliminary experiments indicated that a crib of 1- by 6-inch tongue-and-groove lumber without a lining is not ordinarily tight enough for satisfactory fumigation with carbon bisulfide at the rate of 10 pounds per 1,000 cubic feet of grain. When two layers of kraft paper with an asphalt layer between were used as a lining for the crib, the same fumigant proved effective.

The Minnesota station continued studied on the influence of low temperatures and degree of humidity. In general, the development of the saw-toothed grain beetle was more rapid at the higher humidities. The same station investigated the effect of various foods on the developmental rate, and found that with this beetle, which feeds on almost all stored plant products used for human food, development was more rapid with rolled oats than with walnuts or raisins.

European corn borer.—The New Jersey station in field experiments and hand-infested plats compared a number of hybrids and open-

pollinated varieties of field corn in relation to European corn borer populations at harvest. N. J. Hybrid No. 2 showed a definite resistance to the borer, and for some reason moths appeared to prefer other hybrids and varieties for egg deposition. A definite correlation was indicated between stem hardness and the borer population in the different corns studied.

Plant bugs.—An outbreak of grain plant bugs resulted last year in severe injury to more than 10,000 acres of wheat in one southwestern North Dakota county, damage in many fields being so high that the grain was not worth harvesting. Besides reducing the acre yield and grade of the wheat, these insects seriously damaged its milling and baking qualities. Practices recommended by the North Dakota station to reduce infestations include burning of weeds and trash in which the bugs hibernate, plowing of infested stubble fields during the usual course of summer fallowing, early spring burning of trash cover in narrow strips, especially along margins adjoining cultivated cropland, and working the stubble fields shortly after harvest with various types of subsurface tillage implements to inhibit heavy weed growth late in the season.

Plant lice.—Cooperative studies between the Department and the Illinois and Indiana stations have further demonstrated the differential susceptibility of corn strains and hybrids to the leaf aphid (*Aphis maidis* Fitch). Observations at the Indiana station on 225 inbred and 486 hybrid strains of corn indicated consistent differences among inbred lines in behavior toward aphid attack. Differences in susceptibility ranged from extreme, with 100 percent of the plants infested, to the practical immunity of strains with no infestation. Severity of infestation and the parts of the corn plant attacked also varied, the lower part of the tassels being the most favored point of attack, and the ear, shoots, silks, and upper leaves of the more susceptible varieties also being infested. Individual inbreds differed greatly in prepotency in transmitting susceptibility or resistance to their hybrids, and in general hybrids were less heavily infested than the parental inbreds, although combinations involving one inbred strain provided a notable exception. No plant character or group of characters were found to be consistently correlated with aphid susceptibility.

Wireworms.—For the irrigated lands of the Pacific Northwest, where during their long life cycle of from 2 to 5 years wireworms destroy seed, cut off underground stems, and bore holes in the larger stems, roots, and tubers, cooperative work of the Washington and Idaho stations and the Department (B.E. and P.Q.) has suggested several methods of control. Chemical control methods employed, especially suitable for treating small acreages or land where high-priced crops are grown, are carbon disulfide and crude naphthalene, which act as fumigants to kill the larvae in the soil. Certain cultural practices developed which obviate the expense of chemicals and hence are more practicable for large tracts consist of producing either an excess or a deficiency of moisture in the soil during the summer season to bring about high larval mortalities. Rotations, summer plowing, and planting-date adjustments also lessen the number of wireworms or greatly reduce their damage.

Grape colaspis.—The grubs of the grape colaspis were responsible for extensive soybean damage in Illinois, the yield on thousands of acres having been reduced 10 to 50 percent or more. The Illinois station in cooperation with the Illinois Natural History Survey found that all of the injury occurred where the soybeans followed soybeans or red clover. The methods of combating the pest recommended are fall plowing or early spring plowing of legume sod followed by as many diskings as seem practical considering the cost and the returns to be expected from the crop. If the land is to be planted to corn, planting should be delayed as long as the variety to be grown will permit.

TRUCK-CROP AND GARDEN INSECTS

Potato insects.—An important problem with several experiment stations is that of the potato leafhopper, which in some sections of the country is the most destructive of the potato pests. For instance, the North Dakota station recently found that it constituted 44.6 percent of the total population of all potato foliage pests.

Spraying and dusting experiments by the Iowa station indicated that sulfur dust (325 mesh) and 4–4–50 bordeaux mixture were effective in reducing the leafhopper population and the amount of damage due to hopperburn. The application of these insecticides resulted in a significant increase in yield over all other materials with the exception of derris. Sulfur dust containing paris green was also effective for reducing leafhopper populations but the yield was reduced too, possibly because of some harmful action of paris green on the plants.

The Wisconsin station showed that the percentage of hopperburn development caused by the feeding activities of this pest was greater in early-maturing potato varieties than in late-maturing varieties, regardless of the planting date. Percentage of hopperburn development could be reduced by deferring the planting date with both early and late varieties of potatoes. Nymphal leafhopper population is closely correlated with the percentage of hopperburn development in respect to time of planting. These results indicate that the relative earliness or lateness of a variety is not the prime factor in determining its resistance or susceptibility to hopperburn.

For New Mexico conditions the station in that State found that the adults of the leafhopper could not be successfully eliminated, but that a large percentage of the nymphs were killed by the application of nicotine sprays or dusts.

Observations by the Washington station and the Department (B.E. and P.Q.) indicated that flea beetle populations reached a peak about August 1. Considerable injury to tubers by second-generation larvae occurred about a month after this peak. These studies make it apparent that potato plants should be dusted during July in order to prevent as much second-generation injury as possible.

The potato and tomato psyllid has caused considerable concern in the Great Plains area the last few years and has received the attention of several station and Department entomologists. Results of Wyoming station studies showed significant increases in yield on plats treated with sulfur dust over plats left untreated in all cases where the population of pysllids was high. Sulfur dust gave practically the same control as lime-sulfur, and at a lower cost in small fields since the

equipment cost was less. Plats sprayed with wettable sulfur yielded less than plats sprayed with lime-sulfur. Wettable sulfur had no particular advantage over lime-sulfur and caused frequent plugging of nozzles. The results indicate that it is advisable to dust small fields of potatoes where spraying is not practical or where the cost of hauling water is great.

Tomato insects.—Growers in western New York have encountered serious difficulties in preventing yellowish discolorations on tomatoes known as cloudy spots. The New York State station found that the plant bugs responsible for these spots as a result of their feeding activities could be reduced by the application of an insecticide containing 0.3 percent of pyrethrum.

The tomato fruitworm is the most serious tomato insect pest in Tennessee. Larvae bore into the tomatoes and are capable of destroying 25 percent or more of a crop. The Tennessee station found that where corn was planted as a trap crop among the tomatoes, the infestation was increased. Of the insecticides tested, best results were obtained with three applications of a bait consisting of 10 percent cryolite in corn meal or cottonseed meal applied by hand to the fruit clusters. Cryolite sprays (3 pounds to 50 gallons of water) also gave good control and, according to the station, neither the cryolite baits nor sprays on tomatoes resulted in a residue problem. Cryolite (8 pounds to 150 gallons of water) also gave the best control of this pest on lima beans; magnesium arsenate on the other hand was of no value.

Cabbageworm.—Rather extensive tests have been conducted on Long Island by the New York State station to find substitutes for lead or calcium arsenates as a control of worms on cauliflower and cabbage. There was no significant difference in the protective values of derris, cube, and timbo possessing nearly equal extractive content at a given rotenone strength as shown by the foliage condition of the treated plants. Dust mixtures containing 0.5 to 1 percent of rotenone had nearly equal insecticidal value for control purposes. Rotenone dusts were not as affective as pyrethrum dusts for checking infestations of the cabbage looper, due principally to greater tolerance exhibited by the larger worms toward the toxic effect of rotenone-containing dusts.

Pyrethrum and impregnated pyrethrin dusts containing different diluents, such as clay, talc, air-floated gypsum, sulfur, and diatomaceous earth, were also tested. Mixtures containing talc were found to be of the most practical value as denoted by their effectiveness, dusting qualities, and adaptation to the capabilities of dusting machinery.

COTTON INSECTS

The Texas station conducted tests to determine the effectiveness against the bollworm, bollweevil, and rapid plant bug of a specially prepared calcium arsenate, a commercial calcium arsenate, and a synthetic cryolite. The special calcium arsenate, which contained large particles and a high percentage of water-soluble arsenic pentoxide, gave a significantly better control of the rapid plant bug than the commercial calcium arsenate, but with the bollweevil, although control was better and the yield of cotton higher, the differences were not sig-

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nificant. Calcium arsenate gave significantly better control of weevils than cryolite.

A preliminary test with sulfur-calcium arsenate mixture (2:1) applied at the rate of 15 pounds per acre gave 89-, 39-, and 61-percent control of the flea hopper, rapid plant bug, and bollweevil, respectively. Studies by the same station have shown great variations in the abundance of the cotton flea hopper due to variations in its preferred host plants of the genus *Croton*. This research revealed the importance of *Oenothera laciniata* in the development of an early spring generation of flea hoppers and the importance of *O. speciosa* and the monardas in increasing the flea hopper populations.

FRUIT INSECTS

Codling moth.—The importance of the various locations of hibernating codling moth larvae was found by the West Virginia station and the Department (B.E. and P.Q.) to depend upon the ease with which larvae can find satisfactory places to cocoon. Larvae were not recovered from either soil or the debris beneath any of the trees examined. On well banded and scraped trees, approximately 28 percent of the total worm population was collected on trunk and main scaffold limb bands, 3 percent remained in the harvested fruit, 39 percent was destroyed by predators and other natural factors, 15 percent escaped destruction and emerged, 12 percent was unaccounted for, and only 3 percent overwintered on the trees. Of all surviving larvae, more than 60 percent were caught in trunk and scaffold limb bands. Twigs and limbs less than 4 inches in circumference held approximately 31 percent of the overwintering larvae, while only 5.7 percent were recovered from trunks and 7.4 percent from main scaffold limbs. An overwintering population of 41 larvae per tree gave a first-brood infestation of 36.4 percent the following season.

Observations over a period of 4 years by the Virginia station on the cocooning habits of the codling moth were reported as having shown that on mature, well-scraped apple trees β-naphthol bands captured 69 to 83 percent of the codling moth larvae that cocooned on these trees. The effectiveness of the bands, however, was somewhat lower on unscraped trees, and untreated bands captured a smaller percentage of the larvae than treated. The distribution of the larvae on the trees was little changed by banding or scraping.

The Virginia station studied hardy and weak strains of codling moth larvae in an effort to determine the factors involved in causing a shifting of the character of codling moth population in certain orchards. Its results indicate that the essential difference between hardy and weak strains may be physiological. Oxygen consumption is an index to the basal metabolism and, according to the determinations made during the last two seasons, it appears that the metabolic rate is higher among the weak individuals.

Field tests with so-called dynamite or inverted spray mixtures, in which the particles of solid toxicant are preferentially wetted by oil and thus stick to the sprayed surface, have been studied over a 4-year period by the Pennsylvania station. The run-off in overspraying consists largely of water, and deposits can be built up to high levels. With one such inverted lead arsenate spray timed as a second cover, carrying double the usual concentration of lead arsenate, and

applied at double the usual quantity per tree, control of first-brood codling moth larvae has equaled that obtained with standard schedules of four or five lead arsenate cover sprays, although results to date indicate the desirability of later applications in years of codling moth abundance in orchards subject to reinfestation from adjacent plantings. In certain instances schedules of inverted sprays have saved about one-fifth the cost of the usual schedule of four cover sprays.

Woolly apple aphid.—This insect is a common and destructive pest on the roots of young apple trees throughout North Carolina. No satisfactory method for control of the root form of this aphid has been available, but preliminary experimental work by the North Carolina station has resulted in practically 100-percent control when 0.2 to 1 gram of sodium cyanide in 1 quart of alkaline water per tree was used. Injury to the tree occurred when more than 1 gram was used or when that amount was used in less than 1 quart of water.

Cherry fruitworm.—The Washington station has continued studies on the life history and control of this pest. The station's observations indicate that mature larvae overwinter in stubs of cherry twigs and become adults in late May. Eggs are deposited in sour cherries during June. The young larvae are active during June and become mature in July. There is no evidence of a second generation. Three cover sprays of lead arsenate or cryolite (2½ pounds per 100 gallons of water) applied at intervals of approximately 2 weeks were found to be an effective control, as well as the use of phenothiazine or derris (5 percent rotenone), 2 pounds per 100 gallons of water.

Meadow froghopper.—Investigations by the Delaware station on the dissemination and control of two diseases of peach—peach yellows and little peach—revealed that the meadow froghopper is a carrier of the yellows. The plum hopper has been recognized for some time as a carrier of the virus of both diseases, and now the station has shown that both cultivated and wild plums are the chief factors in their spreading, not only because they breed the plum hopper in large numbers but also because they live longer than the peach and may be infected without discernible symptoms. It is recommended that all plums within a mile of commercial peach orchards be removed.

Scale insects.—Scale insects and mealybugs constitute the major citrus pests in California. Though their control by insecticides is for the most part fairly satisfactory, the cost is high (estimated at $4,000,000 per year for southern California alone), it is generally believed that there is a cumulative bad effect on the trees, and the relation of insecticides to public health is a matter of concern. In 1937 the California station imported a parasite, *Metaphycus helvolus*, from South Africa which has spread with great rapidity and in the fall of 1940 was the most abundant and widespread of the parasites attacking black scale in California. A general disappearance of the black scale in the coastal area during 1940 is attributed by competent observers directly to the activity of this parasite, and it is also credited with being the chief factor in the disappearance of injurious infestations on ornamental plants in Los Angeles county.

Pistol casebearer.—Natural checks on this pest, according to the Pennsylvania station, are low maximum temperatures and thin or light-green foliage during the oviposition period. Predacious and parasitic insects also destroy large numbers of larvae. An artificial

check may be accomplished through sprays. Particularly efficient were midsummer sprays of oil-nicotine or nicotine-penetrol. Two early applications of cube powder killed more than 95 percent of the larvae. Although thorough spraying with a complete schedule of lead arsenate will prevent the insect from attaining dangerous numbers, the other measures are preferable for controlling an outbreak.

Apple maggot.—Studies by the New York State station and the Department (B.E. and P.Q.) showed that complete mortality of apple maggot eggs and larvae results from 32 days' storage at 32° F. and from 45 days' at 36°. Larval activity continues at 40° but eventually most larvae succumb. As a result of these experiments, it is suggested that fruit to be exported should be held for a 40-day storage period at 32° since this period would provide a margin of safety, with time to effect equalization of fruit and air temperature and result in complete mortality.

INSECTICIDES

Nicotines.—The current excess supply of tobacco has made desirable more intensive studies of nicotine compounds since large-scale uses of these products would create increased demand for a domestic agricultural product. The New York (Cornell) station has contributed to the development of more practical nicotine compounds, those most toxic to the bean aphid being nicotine laurate, nicotine oleate, nicotine linoleate, nicotine stearate, and nicotine naphtheanate. When sodium oleate is added as a spreader to nicotine alkaloid, it is of about equal toxicity to these compounds. A second and less toxic division contained compounds with good to poor wetting properties, namely, nicotine alginate, nicotine Aresket, nicotine caseinate, and nicotine humate; a group consisting of dodecyl nicotinium iodide, didodecyl nicotinium diiodide, dodecyl nicotinium bromide, and didodecyl nicotinium dibromide, with excellent wetting and spreading properties; and a group of double salts with saponin as a wetting agent. Insoluble nicotine compounds with little or no toxicity to aphids included silicotungstate, peat, Reineckate, cuprocyanide, bentonite, and resorcinol formaldehyde. These studies suggest that the first group of fatty and naphthenic acid combinations is the most efficient because of the combined toxicity of the alkaloid and the acid, the increase in efficiency due to the wetting and spreading power of the compound, and an unknown activating or synergistic action.

Naphthalene products.—Seeking to find a material equal to or surpassing naphthalene in toxicity to insects, safe for use on plants under glass, and practical under the atmospheric conditions obtained in greenhouses, the Massachusetts station has developed a fumigant mixture (chlornaphthalene oil 3 parts with crystal naphthalene 1 part, used at the rate of one-half liquid ounce per 1,000 cubic feet for 6 hours) which has proved less expensive and more satisfactory than crystal naphthalene alone for controlling red spider on carnations. Inconsistent results were obtained at 50 percent humidity, but complete control followed use of this fumigant at humidities of 70 percent and 80 percent with all temperatures tried (60°, 70°, and 80° F.), and at 70° and 80° with 60 percent humidity.

Oil sprays.—In order to determine the properties most desirable for the various purposes for which petroleum oils in the form of dilute

emulsions are used, methods have been developed by the New York State station for determining the quantity of oil deposited on bark and leaf surfaces. This work has provided a means for the precise measurement of the insecticidal efficiency and plant tolerance of various oil fractions under conditions of the orchard or field, and promises to provide a basis for selecting oils of greater efficiency, specificity, and safeness than those now in use.

As a result of studies by the California station on insecticides, it is indicated that by incorporating certain compounds in oil, the water phase of a spray may materially aid in spreading the oil. This is a new idea in the behavior of oil sprays, and suggests a lead for further research which may prove of considerable value in the development of more efficient oil sprays. The same station also described a method employed in the spraying of citrus leaves in the laboratory and the determination of oil-spray residue according to a simple and rapid technique involving the absorption of the oil from the upper surfaces of the leaves with filter paper and the subsequent extraction of the oil from the paper.

The California station also developed a rapid, simple, and accurate colorimetric method for the determination of oil deposited on citrus leaves by spray oil. This can be used over a wide range of oil concentrations, and consists in the staining of the spray oil with Sudan III. The dyed oil is sprayed as an emulsion and the deposited oil is washed from the leaves with a highly refined light distillate oil or odorless kerosene, and the amount of oil deposited is determined by comparing the color intensity of the unknowns with a set of color standards prepared from the dyed spray oil. Recovery of oil from leaves by the use of the colorimetric method averages 98.41 percent, and the laboratory oil-deposit determinations show an average coefficient of variation of 5.38 percent. Plant waxes and essential oils do not appear to affect the accuracy of the method.

Further studies by the New Hampshire station have corroborated earlier findings that an increase in temperature is accompanied by a decrease in the time required for penetration of an oil ovicide. Penetration of oils into an insect egg becomes more rapid with the lapse of time after the egg is deposited, so that eggs which approach hatching time are more susceptible.

Reaction to HCN.—Efforts directed towards controlling insect pests of plants may be divided into three categories, viz, use of chemicals, parasites or predators, and cultural practices. In each, some knowledge of the peculiar habits and physiology of the insect is necessary to successful consummation. In previous attempts to control the red scale pest of citrus trees by fumigation, it has been noted that some races of this insect were extremely resistant. Studying this problem during the last year, the California station found no observable differences in the structure of the breathing pores (spiracles) between races susceptible and those resistant to hydrocyanic acid gas, and in each race the breathing pores closed within 5 minutes after administering the fumigant. However, in the resistant race they remained closed for at least 30 minutes when the gas was present, whereas in the nonresistant race they remained closed for only about 1 minute and death ensued after opening.

Insect toximeter.—An insect toximeter was developed by the New Hampshire station by means of which accurate studies can be made of contact materials applied to living insects under controlled conditions. By use of this apparatus, individual insects in lots of 10 are subjected to accurately controlled applications of contact sprays. This development is proving useful in conducting rapidly replicated experiments on various contact insecticides against different species of insects.

BIOLOGICAL CONTROL

Complete or partial control of an insect pest by natural enemies has proved of great value to the agricultural industry in many instances. Experiment station and Department entomologists, often in close cooperation, have contributed a great deal to our knowledge of factors governing the success or failure of this means of control. Recently the California station has shown that the establishment of parasitic wasps may be resisted by environmental factors which affect the activity of the ovipositing females or the development of their progeny. Parasitic species may fail to become established because they do not frequent host habitats or because they frequent habitats which lack hosts. The density of hosts may be reduced below that required for the maintenance of the parasite population by the use of insecticides. The establishment of parasitic populations may fail if the deposition of fertilized eggs of colonized adult parasites is inhibited by a change in condition of the host, the presence of predators, lack of food, or if the development of the parasite progeny is inhibited by the unsuitability of its normal host or by the competition of other parasites, either primary or secondary.

In a study of the effect of varying conditions on oviposition by *Trichogramma* on eggs of angoumois grain moths, the Puerto Rico station concluded that *T. minutum* is not equally efficient as a parasite in all environments. Its response to the environment determines, to a great extent, its parasitic potential.

BEE CULTURE

Observations by the California station and the Department (B.E. and P.Q.) under field and greenhouse conditions indicate that alfalfa-nectar-secretion and the sugar-concentration values are affected by length of day, longer days tending to stimulate earlier blossoming, which lengthens the seasonal nectar-secretion period in alfalfa. Turkestan alfalfa was found to yield more and richer nectar than common alfalfa, and larger blossoms provided a greater amount of nectar than small blossoms. Continuous warmth under greenhouse conditions resulted in maximum secretion. Sugar concentration was increased by lowering soil moisture and by lowering the relative humidity of the atmosphere.

In the foothill orchards of California buckeye has been an important factor in the failure of many fruit growers' attempts to keep bees successfully. This is due to the fact that when a high percentage of buckeye products is received in the food of the bees, a condition soon arises in which only eggs, day-old larvae, and sealed brood are present, the absence of unsealed brood constituting a typical symptom of "buckeyed" colonies. Later only eggs are found in the cells. The

California station and the Department have studied the distribution of this plant and published maps which show the upward limit of buckeye in the State. Such information should be a great aid to beekeepers and orchardists trying to decide on localities where the enterprise might be put on a profitable basis.

ANIMAL PRODUCTION, PRODUCTS, DISEASES, AND DISORDERS

CONTENTS

Livestock producers encounter many and varied problems in breeding, feeding, and management, many of which are complicated by physiological aspects. Attempts at the solution of the problems are varied and cover a wide range of subjects. Some of the research accomplishments of the year are here briefly reviewed.

LIVESTOCK PRODUCTION, FEEDING, AND MANAGEMENT

More refined and precise methods of measuring the value of feeds for the production of growth and increased amounts of salable products of superior quality have directed attention to the quality of the nutrient as well as the product. It therefore becomes of importance to know more about the role and end products of metabolism.

Nutritive values of feeds.—Productive-energy values were calculated by the Texas station for several feeds. Considering the heat and weight produced by chickens on a basal ration in comparison with the production when the ration was supplemented with the feed to be tested, they ranked in the order corn meal, corn bran, corn gluten meal, and cottonseed flour; casein; cottonseed meal; wheatgrass; and tankage. The productive energy of both cottonseed hulls and oat hulls was practically nil.

The Washington station showed that as the season advanced the ash, fiber, and nitrogen-free extract of crested wheatgrass and sweetclover hay increased in amount, but the nutrients were better digested in immature grasses.

Vitamin studies.—The Pennsylvania station found that B_1 requirements of rats were increased with physical exercise. With no vitamin B_1, feed consumption and growth rate were reduced. Deficient rats became progressively less active as the experiment progressed.

In a series of vitamin A experiments at the Texas station the time required to deplete cattle varied with the age and size of the cattle. There was less reserve in younger animals. The 3- to 6-month-old group required an avergae of 56 days to develop night blindness, whereas 178 days were required by the group 16 months of age to develop a similar condition.

Synthesis of vitamin B components.—The California station found that thiamin (B_1) and pantothenic acid components of the vitamin B complex were synthesized in the rumen of cattle and sheep. At the Texas station, riboflavin, pyridoxin, and vitamin K were found to be synthesized in the rumen. The Ohio station found that riboflavin was synthetically produced in the rumen of beef cattle, and the Wisconsin station that heifer calves were able to synthesize thiamin, riboflavin, nicotinic acid, pantothenic acid, pyridoxin, and biotin in the rumen. Significant amounts of these vitamins were present in the rumen contents even though the rations were low or devoid of these substances.

Other nutrition problems.—In an attempt to obtain a clearer understanding of the values of damaged products, the Illinois station found specific fungi to cause definite changes in the chemical composition of damaged corn. One sample of corn containing 53 percent of kernels damaged by one of the organisms proved extremely toxic to young albino rats.

BEEF CATTLE

Because of the expense and time required beef cattle investigations were limited largely to feeding, nutrition, and management.

Feeding trials.—In studies of energy production in rations containing different percentages of protein, the Illinois station found that the utilization of energy by beef cattle was not significantly modified by variations in the protein level between 6 and 20 percent. Apparently, the feed energy was utilized as efficiently for fattening as for growth.

No deleterious effect accompanied the use of wheat and rye in equal proportions when fed with alfalfa and grass hay at the Oregon station. A high dressing percentage, with cattle attractive to buyers, resulted. The same amounts of grain were consumed when molasses was added to the ration, but the rate of gain was reduced.

Peanut meal and cottonseed meal gave similar results as supplements to corn and silage for yearling Hereford steers at the Georgia station. Ground peanut hay produced average daily gains of approximately 2 pounds per head, as compared with somewhat smaller gains when whole peanut hay, silage, or cottonseed hulls were employed as the roughage supplementing corn and cottonseed meal. Advantages of grinding peanut hay for yearling steers depended on the relative costs of the grinding operation.

Pastures and roughages.—At the Michigan station, legume silage was somewhat less favorable than corn silage, unless a satisfactory protein-rich supplemental feed was employed, for feeding heifer calves. At the North Dakota station, good clean beet-top silage was worth from one-third to one-half as much as corn silage for fattening steer calves. Sorghum silage proved superior to Napier grass and sugarcane silage in 3 years' studies with yearling steers at the Florida station, where average daily gains with sorghum silage of over 2 pounds not only exceeded the rate of gain with other silages but also less digestible nutrients were required per pound of gain than from sugarcane and Napier grass silage. The Pennsylvania station investigated the merits of alfalfa-molasses silage as a feed for fattening steers, finding that when corn-and-cob meal was fed there were produced about the same results as those from corn silage. The gains

made were somewhat reduced, and less finish was attained when alfalfa alone was fed with the corn-and-cob meal. The returns per unit of corn-and-cob silage were superior to those with alfalfa hay, but there was no advantage over alfalfa hay as a sole roughage.

Cattle finished on pasture at the Illinois station dressed and graded lower and had a higher shrinkage than cattle finished in dry lot. The West Virginia station investigated finishing steers with grass and grain and found that the amounts of grain required did not differ greatly whether fed with pasture or in dry lot at the conclusion of the pasture period. When grain was fed during the grazing season, slightly better finish was attained.

The Texas station found the financial returns from Sudan grass pasture for beef production did not favor supplemental feeding, although greater total gains and better market finish were attained. Creditable finish of heavy yearling steers was induced in a 140-day feeding period with cottonseed cake or ground corn in addition to the Sudan pasture.

Mineral requirements.—Calcium and phosphorus are the principal mineral nutrients required in addition to the regular rations for cattle. The Kansas station found no significant effects on appetite, digestible nutrients, dressing percentage, or carcass grade from limestone supplements to the fattening ration of shelled corn, cottonseed meal, and sorgo silage, but the steers receiving calcium supplements required less feed per unit of gain than those on low-calcium rations.

At the Idaho station the phosphorus requirements for fattening steers were met by rations containing 0.18 percent or more of phosphorus from adequate amounts of bonemeal, cottonseed meal, or meat meal as supplements to a basal ration of beet pulp, chopped alfalfa, and blood meal. Large amounts of phosphorus seemed to interfere with the utilization of feed, gains were reduced, and more feed was required per unit of gain.

Since copper has been suggested as having a possible curative effect, the Florida station examined the tissues of calves produced by salt-sick and normal cows but was unable to find significant differences in the content of copper or other trace elements. Practically all of the tissues contained zinc, aluminum, and manganese.

SHEEP

Finishing lambs.—When fed to replace one-half of corn for fattening lambs, the Oklahoma station found oats and barley only 89 and 72 percent efficient, respectively. The values of the mixture of oats and barley were slightly greater than the combination of corn and barley. Lambs fed corn as the only grain yielded the highest- and those fed barley the lowest-grading carcasses.

At the Michigan station gains and finish were reduced when 30 percent of corn instead of equal amounts was fed with alfalfa hay for fattening lambs.

In an investigation by the Wyoming station, the gains of lambs were reduced when bean straw was fed in place of alfalfa hay. Gains were increased, however, when the roughage consisted of equal parts of the two products. Bean straw alone caused scouring but this could be prevented by supplementing cured beet tops. The Missouri station

obtained slightly more rapid gains with the early lambs than with late lambs.

Management studies.—The Texas station crossed Merino and Rambouillet ewes from a horned stock with Dorset horned rams and produced especially attractive ewes for the production of fat lambs when bred to mutton rams. When native ewes were mated by the Mississippi station with purebred Corriedale, Hampshire, and Southdown rams, approximately equal advantages were shown for the lambs at market time. A slight advantage in compactness was evident for lambs of Southdown breeding.

SWINE

Calcium and magnesium needs.—The general practice of feeding minerals to swine gives recognition to the fact that many rations furnish inadequate amounts of minerals and that a pathological condition may result from deficiency of specific minerals. Stiffness, enlarged hock joints, and crooked legs were noted by the Pennsylvania station when a weight of 150 pounds was attained by one-half of the pigs fed yellow corn, tankage, soybean meal, ground alfalfa hay, and salt. This condition was prevented but not cured by supplements of magnesium sulfate. The Kansas station found a level of 0.25 percent of calcium to be slightly below the minimum requirement for swine when the level of phosphorus was 0.3 percent and adequate vitamin D was furnished. A ration containing 0.41 percent of calcium produced normal development and was considered adequate under these conditions.

Requirement of thiamin and riboflavin.—The California station concluded from studies of the effect of graded doses that swine require about 1 milligram of thiamin and 1 to 3 milligrams of riboflavin per 100 pounds live weight of growing pigs per day.

Feeding tests.—Sows fed a ration of corn, tankage, linseed meal, and alfalfa meal with cod-liver oil at the Missouri station showed this ration to be partially inadequate. Subnormal feed consumption was noted and occasional lameness, scanty hair, scaly skins, and unsteadiness when standing or walking. Some of the litters were practically normal, but many developed these and other abnormalities, including skin lesions, muscular weakness, incoordination, diarrhea, and death.

In other investigations the Mississippi station found that when ground corn and ground barley were self-fed with tankage the average daily gains produced were 1.9 and 1.7 pounds, respectively, but when ground oats replaced these cereals the gains were reduced to about 1.5 pounds per head daily and the feed requirement per unit of gain was increased. There was a greater amount of grazing by barley-fed lots of pigs. Very slow gains were obtained by the Kentucky station from feeding distillery slop alone, and soft and oily carcasses were produced.

Different levels of protein supplementing concentrate mixtures of corn, tankage, soybean meal, and salt were compared by the Pennsylvania station when pigs were fed on alfalfa and red clover pasture. Eighteen percent of protein was required between weaning and 130 pounds live weight when grazing rape pasture, but a 12-percent protein mixture was adequate on alfalfa or clover pastures after 70 pounds live weight was attained. These gains were not considered economical, and from 15 to 18 percent of protein was recommended for the pigs on

all three types of pasture from live weights of 40 to 210 pounds. Lower protein levels seemed adequate for pigs of the heavier weights.

In studies at the Michigan station, heat-treated soybean meal proved more palatable and was more efficiently utilized than raw solvent meal. Practically as good gains were made as with tankage when fed with corn, barley, and alfalfa. A method for the production of firm carcasses from pigs fed soybeans was provided by studies at the North Carolina station of changing from rations containing 30, 40, and 50 percent of mature soybeans after 100 pounds' weight was attained to rations containing corn and tankage with 13 percent of cottonseed meal until an average weight of 230 pounds was reached. The carcasses from such hogs were firm. Soybean meal produced by the extraction, hydraulic, and expeller methods was found by the Ohio station to have a relatively high value as a protein supplement for swine. Pigs receiving soybeans with minerals were ready for market only 4 days later than pigs receiving a supplement of tankage.

Curing and storing pork products.—Tests of treatments of pork-loin roasts for freezer-locker storage by the Kansas station showed that double-wrapped roasts lost less weight than those stored in single wrappings. Roasts rolled in oat flour browned more satisfactorily upon cooking than roasts normally prepared, and the amounts of loss by oxidation were reduced. The storage period in freezer lockers was not greatly different with sausages preserved by different methods, but the roasts and sausages should not be stored longer than 150 days.

POULTRY

The small size, rapidity of reproduction, and relatively slight individual value makes it possible to investigate various phases of poultry production at lower costs than are required for similar studies with other classes of animals.

Protein needs and feeds.—The Texas station made a study of the metabolizable energy values of various feeds for chickens and concluded that rations containing 6 percent of vacuum-dried fish meal produced greater gains with less feed required per unit of gain than when fish meal was not fed. Liver meal was not a satisfactory substitute for fish meal. Cottonseed meal and soybean meal were of about equal value when fed with other protein supplements, but neither peanut meal nor linseed meal proved as effective. Additions of whey as a source of vitamin G did not improve a protein supplement containing 6 percent of fish meal and 5 percent of dried alfalfa meal, although combinations with alfalfa meal but no fish meal were improved by the inclusion of this product.

An evaluation of different protein supplements for poultry by the Washington station gave the highest rating for herring fish meal. In considering weight increases in fryers and roasters, the South Dakota station found that corn and wheat rations produced more rapid growth than barley rations and corn-fed birds graded better.

Protein levels of 12 to 25 percent in the hen's ration were found by the Oklahoma station to have a marked influence on the weight of newly hatched chicks. The higher levels of protein reduced the weights of the chickens as compared with medium- or low-protein levels. By analyses of variance of egg and chick weights, correlations

showed that 12 percent of the variation of the chick weight at hatching was due to factors other than variation in egg weight.

The Washington station found that as much as 50 percent of standard mill run, added to the mash, did not seriously influence the egg-producing ability of the hens or mortality of the chicks. However, replacement of 35 percent of the ration with mill run gave slightly better results, and proved superior, as well, to the feeding of 20 percent of mill run in the mash.

Up to 12 to 15 percent of the total crude protein in the ration of growing chicks and laying hens was satisfactorily provided by distillers' dried solubles at the Minnesota station. This product also furnished a considerable quantity of riboflavin and produced growth comparable to that on experimental rations which had been fortified with this vitamin.

At the Iowa station, when soybean meal was added to the chick ration no significant effects on growth rate were produced until more than 10 percent of oil was included. Hatchability of eggs was improved at the Colorado station by the replacement by casein and oat groats, wheat bran, and wheat scraps of a part of the soybean meal in a mash ration containing cereals, brewers' yeast, vitamins, and minerals, and still further improved with a cereal mixture. The goitrogenicity of soybean meal resulted in a depression in reproduction on account of the stimulation of the hypophysis. Feeds low in iodine were beneficial. The New York (Cornell) station showed beneficial results on growth from additions of potassium iodide.

At the South Carolina station the addition of 3.6 percent of cottonseed oil to a control ration reduced the hatchability of the eggs from 75–85 percent to 27.8 percent, but soybean oil, Wesson oil, and hydrogenated cottonseed oil failed to depress hatchability. The deleterious effects of cottonseed oil were not removed by heating or oxidation or corrected by vitamins A, D, and E or pork-liver supplements.

In a series of experiments at the Tennessee station, legume silage to which certain preservatives, such as molasses, sour skim milk, and powdered buttermilk, were added proved to be a desirable addition to the rations of chicks, laying hens, and ducks. Higher daily feed consumption, increased appetite, and greater weight resulted, and the appearance, vitality, and egg production were improved.

Vitamins.—Yellow carrots were found by the Michigan station to make a good source of carotene when employed as a substitute for green feed for poultry.

The Wisconsin station investigated the effects of different supplements, when given singly and in combination, upon the growth of chicks. These included liver extract, thiamin, riboflavin, nicotinic acid, pantothenic acid, vitamin B_6, and the U factor added to a modified diet of yellow corn, casein, salt, cod-liver oil, and cottonseed oil. Additions of small amounts of these supplements proved to give favorable results, but in cases of some (particularly nicotinic acid) toxic effects were produced by large amounts. There were no benefits on egg production, hatchability, fertility of the eggs, or viability of the chicks from supplementing a well-balanced ration with wheat-germ oil.

A type of dermatitis in the chicken distinct from, and more severe than, that caused by pantothenic acid deficiency, was observed and described by the Wisconsin station. Symptoms of anemia, dermatitis,

and perosis were produced by the Missouri station on experimental rations prepared to bring about these conditions after increasing the growth rate by supplementing rations with vitamin B_6. The optimum amounts of this vitamin for baby chicks ranged between 300 and 500 micrograms per 100 grams of feed consumed.

The Maryland station found that riboflavin prevented the appearance of curled-toe paralysis in chicks and increased the growth rate. Attention was also called to the possibility of destroying riboflavin in natural feeds and the use of less rich sources of the substance to cheapen the ration for larger birds for which the requirements were greater. An alcohol-precipitate factor from dried brewers' yeast was found which had a greater effect than riboflavin on the maintenance of body weight in laying hens. This factor proved to be water-soluble and stable to boiling.

Since vitamin K-deficient chicks cannot utilize vitamins adsorbed on charcoal, feeding charcoal with a normal diet supplying adequate but not excessive amounts of vitamins induced vitamin A and K deficiencies, gizzard erosion, and curled-toe paralysis. Without charcoal the abnormal conditions did not appear. Thus the adsorbing power of the charcoal in poultry rations may not be entirely beneficial.

Mineral needs.—In investigations by the Washington station, chicks showed increases of 36 to 44 percent in the bone ash during the first 9 days of age. When the diet was deficient in vitamin D and minerals, the bones decreased from 36 to 28 percent and to lower levels when the feeding period was continued.

At the California station chicks were found to require a supplement of at least 0.172 percent of potassium in a diet devoid of this element to induce maximum growth. Rubidium added to a ration containing 0.072 percent of potassium slightly stimulated growth.

The practice of feeding sulfur for the alleviation and prevention of coccidiosis in poultry was found to be questionable in an investigation by the Wisconsin station. The pullets on a ration containing 2 to 5 percent of flowers of sulfur laid well until January, but later production declined, shell texture became poorer, and many of the pullets were down with egg paralysis.

Management of poultry.—The cage system of poultry management following intensified production was recommended by the New Mexico station for poultry raisers located near good markets. Laying hens kept in individual cages produced an average of 34 more eggs per year than comparable birds in open pens. Mortality was also lower in the cage-hatched birds, but management costs and feed consumption were slightly greater.

The California station showed that the dams' records alone for the winter months or for the year were of little or no value in selecting daughters for breeding, but an index based on the dams' sisters' production was derived which proved of special value. The winter months' production of the sisters' progeny seemed to give as efficient an indication of the productive capacity of the progeny as all-year trap-nesting.

Poultry meat production.—The South Dakota station found carcass measurements of Rhode Island Red roasters to show a close correlation with the dressed weight, and the conditions of fleshing were indicative

of carcass quality. In this connection the Kansas station found the development of musculature, amount and distribution of fat, and the shape of the body to be helpful in determining market grade in poultry.

In studies of changes in body form of male and female chicks during growth, the Oklahoma station showed that the shank length increased with body growth only up to 16 and 12 weeks, respectively. White Leghorn and Barred Plymouth Rock chicks and crosses of hens of these breeds with Cornish males were studied. At the California station satisfactory selection of improved meat type among birds of the same age was effected by determination of the shank length.

The Arkansas station found that broilers from Rhode Island Red females × White Wyandotte males were superior to either parent in rate of growth, feed requirements, viability, and completeness of feathering. However, because of the columbian color pattern, such broilers were considered undesirable for market production.

Investigations at the Michigan station indicated that Cornish strains had a slight advantage over White Leghorns and Rhode Island Reds for the production of roasters. At 36 weeks of age purebred and crossbred White Cornish × Barred Rock birds gave best results, and crossbreds were easily distinguished because of the dominance of the pea comb of the Cornish males. Hybrids of Cornish origin could thus be identified.

Quality of eggs.—The New Jersey station found egg quality to be inversely related to evaporation losses, which were greater in eggs held at higher temperatures. The degree of shell mottling was not related to the height of the thick albumen, as ascertained after the eggs were opened. Both degrees of shell mottling and size of the air cell were results of the rate of evaporation.

Turkey production.—In a comparison of free-choice feeding of corn, wheat, oats, and barley with mash for standard Bronze turkeys, the Michigan station found that oats was preferred to the other grains. In a study by the Washington station, a limestone supplement was especially needed by turkeys when feeding corn, wheat, oats, and barley.

The inclusion of yellow corn and wheat in the rations of poults from 8 to 26 weeks of age was found by the Wyoming station to produce better-fleshed carcasses than barley, oats, and rye, although rye rated high in the rate of gains produced.

In experiments by the Indiana station, poults grew well on a 20- to 23-percent protein feed, suggesting that poults require more protein during the starting period than chicks.

Turkeys boned, smoked, and cured, in investigations at the Michigan station, resulted in a more pleasing and usable product.

Incubation of pheasant and quail eggs.—The use of artificial incubation for pheasant and quail eggs at the New York (Cornell) station showed differences in the humidity, temperature, and air movement required as compared with hens' eggs. Pheasant eggs hatched best with a low temperature, high humidity, and slow air movement, whereas quail eggs seemed to favor a low temperature, medium humidity, and slow air movement for optimum hatching.

DAIRY CATTLE AND PRODUCTS

Roughage rations for dairy cows.—The ability of the cow to consume and utilize large quantities of roughage, coupled with the abundant production and relatively low market value of pasture, hay, and silage crops, provides a strong stimulus for investigations on ways of utilizing maximum amounts of forage crops for dairy animals.

The Oregon station has established the fact that both growth- and lactation-promoting properties of alfalfa crude proteins are limited by deficiencies of essential amino acids. It has also found that dairy cattle restricted to alfalfa hay as the sole ration receive an inadequate amount of phosphorus. Cows fed only alfalfa hay over complete lactation periods produced about 78 percent as much milk as comparable groups fed a limited amount of concentrates with alfalfa. The Michigan station found that cows fed alfalfa alone produced only 50 to 60 percent as much milk as those fed alfalfa liberally supplemented with grains. The replacement of part of the alfalfa with corn, oats, or beet pulp caused a marked increase in milk production, but additions of glucose, cornstarch, cystine, choline, yeast, or vegetable oils gave little or no response, indicating that alfalfa is deficient in certain factors contained in the whole grains or beet pulp, but not supplied by the purified adjuncts. At the West Virginia station, a ration of alfalfa, corn sugar, and minerals failed to produce normal gains in dairy heifers and did not support moderate milk production. On the other hand, production was satisfactory with alfalfa, yellow corn, and ground oats with pasture in season.

Findings of the Washington and Oregon stations agree that milk production on alfalfa hay alone may yield a higher net return over feed costs than when supplementary grain is fed, depending on the price received for milk or butterfat.

The Vermont station found that dairy animals fed good-quality hay plus concentrates to balance the ration seldom need vitamin or mineral supplements for normal growth, reproduction, and lactation. When poor-quality hay was fed, supplements of vitamins A and D were of some value but they did not equal good-quality hay in promoting growth.

Tests at the Wisconsin station gave evidence that simple home-grown rations are adequate for growth in dairy heifers. When alfalfa hay was fed with corn and oats, additions of wheat, bran, or bonemeal failed to improve the ration. Timothy hay, corn, and oats provided too little protein for optimum growth, but the simple addition of protein from corn-gluten meal made it effective.

At the West Virginia station a ration of timothy hay, yellow corn, and corn-gluten meal proved inadequate for growth, reproduction, and milk production. One of timothy hay, corn silage, yellow corn, soybean meal, and minerals was entirely adequate.

The North Carolina station compared the digestibility of early- and late-cut grass hay, the former averaging 15 to 20 percent more digestible than the latter. This fact, coupled with the higher crude-protein content of immature grass, resulted in an appreciably greater yield of digestible protein per acre from hay cut in mid-July than from August-harvested hay.

Cull apples were found to be a desirable supplement to hay and grain for milking cows in trials at the Virginia station. When compared with corn silage valued at $4.50 per ton, the apples were worth $2.36 per ton.

Preservation of roughage by ensiling.—Numerous trials were conducted on the use of phosphoric acid as a preservative for grass and legume silage. Trials at the Wisconsin station indicated that alfalfa silages prepared with 20 to 30 pounds of phosphoric acid per ton and those receiving 65 pounds of molasses per ton were of about equal quality as judged by color, odor, and chemical analyses. Tests with other materials as preservatives indicated that the addition of 150 to 200 pounds of finely ground corn per ton of silage gave results comparable to 60 pounds of molasses. A significant finding at the Pennsylvania station was that carotene was retained equally well in legume silages preserved with molasses or phosphoric acid during the early months of storage, but in late storage the carotene destruction progressed much more rapidly in that containing the phosphoric acid. The Missouri station found that green barley, either chopped or in bundles, could be successfully ensiled in trench silos with the addition of either 60 pounds of molasses or 8 pounds of phosphoric acid per ton. Analyses of a wide range of legume-grass silage at the New Jersey station indicated losses of 10 to 15 percent in total dry matter during ensiling. The percentage loss of protein was generally greater than of dry matter, particularly in protein-rich crops. When fed in combination with some hay or corn silage, legume silages preserved with molasses or phosphoric acid were practically equal in feeding value for milking cows in trials at the New York (Cornell), Pennsylvania, and New Jersey stations. When fed as the only roughage at Cornell, phosphoric acid silage caused acidosis frequently accompanied by an unthrifty condition in cows, but the inclusion of some legume hay or ground limestone in the ration overcame the difficulty.

The Michigan station found that legume silages which underwent butyric acid fermentation or were browned by high temperature in the silo were low in total digestible nutrients as compared with high-quality silage.

Broomcorn stalks ensiled with addition of 5 percent of molasses made a satisfactory silage at the Illinois station.

Proteins for dairy cattle.—Following an earlier finding that growing dairy heifers can utilize urea, a nonprotein compound, in meeting the nitrogen requirements for growth, the Wisconsin station carried the experiment to lactating cows and found that when it was added to a low-protein dairy ration, urea compared favorably with linseed meal as a source of nitrogen for milk production. The conversion of urea nitrogen into usable protein was found to take place in the rumen of cows as a result of bacterial action.

Previous work by the Missouri station has demonstrated the effectiveness of thyroid substance or thyroxine in stimulating increases in milk production, fat percentage, and total milk and milk-fat production of cows and goats, but economic application of these findings has not been feasible because of the high cost of the substances used. During the last year it was found that a relatively inexpensive artificial thyroprotein possessing all of the properties of thyroid substance

can be produced by chemically combining the proteins of skim milk with iodine.

Extended nitrogen-balance experiments with dairy heifers at the New Hampshire station have led to the conclusion that the commonly accepted standards for feeding growing animals of this type are unnecessarily high in protein. Since protein represents a costly factor in feedstuffs, a material saving might be made by the use of feed mixtures containing a lower protein content.

The role of vitamins in dairy-cattle nutrition.—Numerous investigations have further demonstrated the requirements of dairy cattle for various vitamins and also that the potency of certain vitamins in milk is quite closely related to the level of intake. The Oklahoma station found that when the average daily carotene intake during the last 90 days before calving falls below 40 micrograms per pound of body weight normal reproduction is generally impaired. A half-normal allowance of prairie hay was sufficient to meet this requirement, but when the prairie hay consumption was limited to 4 pounds or less per cow daily symptoms of vitamin A deficiency resulted. Plasma carotene values less than 100 micrograms per milliliter in calves and 150 micrograms in pregnant cows were found to precede vitamin A deficiency.

Observations of the relatively low vitamin A content of milk produced by cows limited to dry winter feeds have been confirmed by the Alabama and New Mexico stations. The former found that access to winter pasture crops such as rye or clovers more than trebled the vitamin A in winter milk as compared with that from cows on dry feeds. The latter station found that the milk fat from cows fed hegari fodder and cottonseed meal plus access to Sudan grass pasture contained nearly six times as much carotene and vitamin A as that from cows without access to the pasture.

At the New Jersey station, milks produced on grass-legume silages during winter months were practically equal in carotene content to milk produced on spring pasture. In addition, the flavor of the milk produced on the grass-silage ration was definitely superior to that produced on corn silage, dried beet pulp, or dried citrus pulp.

Studies at the New York (Cornell) station led to the conclusion that the riboflavin content of milk can be influenced only to a very limited extent by the diet.

The role of ascorbic acid (vitamin C) in cattle nutrition is not yet clearly understood. There is some evidence that the cow can synthesize vitamin C. On the other hand, the Pennsylvania station found that ingested ascorbic acid was rapidly destroyed in the bovine rumen, and that the feeding of massive doses of this factor failed to increase its concentration in the blood or milk and only slightly in the urine. However, injection of ascorbic acid was promptly reflected in increased concentrations in the blood, milk, and urine. Trials with milk goats at the North Carolina station indicated that the content of ascorbic acid in the blood and milk was not closely dependent on that in the diet. Mastitis infection in the udders of dairy cows was found to reduce significantly the ascorbic acid content of the milk, according to the Missouri station.

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The South Dakota station has conclusively shown that cows maintained on vitamin D-deficient rations and with no sunshine developed avitaminosis D. Generous amounts of calcium and phosphorus in the ration exerted neither a preventive nor a curative effect against this condition, but the addition of only 2 pounds of alfalfa daily to the ration supplied sufficient Vitamin D to bring about marked rapid improvement. The Arizona station found that cows exposed to the sun's rays produced milk practically twice as potent in vitamin D as those confined in dark stalls.

Factors in milk secretion.—Marked progress has been made within recent years in identifying the specific blood components which serve as precursors of milk constituents.

The Minnesota station demonstrated that the uptake of fat from the blood stream by the mammary gland is limited to neutral fat and the cholesterol fraction. Sufficient quantities of these are absorbed to account for all milk fat produced. The Connecticut (Storrs) station has shown that ketone bodies, normally present in limited concentration in bovine blood, are used by the active mammary gland. However, only the β-hydroxybutyric acid portion of the ketone body is so used. It appeared likely that this compound is the precursor of short-chain fatty acids in milk.

The Missouri station obtained evidence that a part of the blood sugar is conjugated with the proteins of the blood and that this glycoprotein is freely absorbed by the lactating mammary gland. The results indicated that the blood globulins which contain the glycoprotein are the primary source of milk protein. No evidence has been secured to indicate that free amino acids are major precursors of milk proteins.

In further studies of factors influencing the letting-down of milk by the cow, the Minnesota station found that excessive manipulation of the udder 20 minutes before milking caused an appreciable decrease in milk and more particularly in fat yield. Rapid milking was conducive to large milk flow. When individual quarters were milked successively, there was a progressive decrease in milk yield which was demonstrated to be due to failure of completely letting-down the milk. It is believed that handling of the udder stimulates release of an oxytocic principle by the pituitary gland and that lower production due to manipulation of the udder before milking or a prolonged milking process is due to dissipation of the oxytocic principle in the blood.

The New York State station obtained evidence that unfavorable results are obtained from use of the milking machines when the unit remains on the cow for 9 to 10 minutes. However, by limiting the time of machine milking to 4 or 5 minutes the monthly butterfat production and the persistency of production was very similar to that resulting from good hand milking, thus further emphasizing the importance of rapid milking.

Milk processing.—In studying the effects of various methods of farm milk cooling, the Louisiana station found that a delay of 2 hours before cooling did not adversely affect the quality of milk when it was rapidly chilled by a conical or tubular cooler but that it did cause a 65- to 100-percent increase in bacterial count when cooling was accomplished by submerging 10-gallon cans in a cooling tank.

The Nebraska and Pennsylvania stations agreed in finding that well water at a temperature above 50° F. is not an effective milk-cooling

medium and that a marked increase in bacterial count occurs when milk is held overnight in such storage. The latter station found that 90 percent or more of the total bacteria were generally present in the top or cream layer of a can of milk held for 12 hours, indicating the need of maintaining the cooling medium at a sufficient depth to cool the entire can during overnight holding.

High-temperature, short-time (flash) pasteurization of milk has been studied extensively. This process is recognized to have certain advantages over the conventional holder method of pasteurization, although its use is not yet legalized in many States.

Extensive tests at the New York State station comparing the effectiveness of pasteurization temperatures ranging from 140° to 175° led to the conclusion that pasteurization at 170° for 1 second was most desirable when judged on the basis of destruction of bacteria, inactivation of phosphatase, and effect on creaming ability and flavor of the milk.

From experiments with commercial equipment at the New York (Cornell) station, pasteurization at 161° to 163° for 22.5 seconds proved equal or superior to the conventional holder method. Similar results were obtained at the Michigan station.

To attain the bacteria-killing property of pasteurizing at 143° for 30 minutes, the Illinois station found that 150° F. for 8½ minutes, 156° for 2½ minutes, or 160° for 47 seconds was required. Phosphatase was inactivated in somewhat shorter periods at all temperatures.

The Pennsylvania station confirmed the value of the phosphatase test for detecting inadequate pasteurization of milk. It showed that the accuracy of the test is not impaired by fortifying milk with vitamin D, by additions of pancreatic enzyme, metallic contamination, development of oxidized flavor, homogenization, or prolonged storage under refrigeration.

The Iowa station has demonstrated that many genera and species of bacteria and molds growing in milk or butter synthesize the enzyme phosphatase. It is evident from these findings that the phosphatase test cannot accurately be applied to butter as a means of determining the efficiency with which cream has been pasteurized.

Off-flavors in milk.—The most prevalent and annoying off-flavor encountered in the handling of market milk is the tallowy flavor resulting from oxidation commonly known as "oxidized flavor." In further studies of antioxidants which may be used to inhibit this defect in milk and its products, the Pennsylvania station found that concentrated extracts prepared from either corn or oats were highly effective, while extracts of soybean flour were less potent. The Massachusetts station reported that raw sugars exerted marked antioxidant properties when added to milk products, while refined sugars were of less value in this respect. Extracts of cocoa powder and also cocoa shells gave promise as sources of antioxidants. The Illinois station found that the amino acid tyrocine and its butyl ester when added to milk at the rate of 0.02 to 0.03 percent were effective antioxidants. A low concentration of pancreatic enzyme was similarly effective. This station also confirmed the effectiveness of various cereal products for this purpose.

The West Virgina station was able to influence significantly the susceptibility of milk to oxidized-flavor development by varying the

amount and the source of fat in the ration. Soybean oils increased the iodine number of the milk fat and the susceptibility to oxidized flavor, while both were reduced by the feeding of coconut oil.

In further studies on the source-origin of activated flavor in irradiated milk, the Wisconsin station obtained evidence that the protein fraction of the milk is responsible. More specifically, it appeared that the amino acids cystine, methionine, tryptophan, and histidine are important contributors to this defect.

Rancidity resulting from enzymatic splitting of the fat in milk and milk products is another serious defect. Findings of the New York (Cornell) station indicate that the rate of lipolysis in raw milk or cream is markedly influenced by the physical state of the butterfat. Cooling, warming, and recooling markedly increased lipolysis. The California station found that prompt cooling of the milk activated the enzyme, but when milk was held at 90° or above for 1 to 3 hours after milking, lipase activity was greatly reduced even though the milk was subsequently cooled. The California and Minnesota stations agreed in showing that other undesirable results, particularly a reduced curd tension and prevention of rennet curdling, may result from lipolysis of milk, evidently due to the release of certain free fatty acids. That lipolysis in whole milk is increased by shaking has been demonstrated both at the New York (Cornell) and the Wisconsin stations, and also that cream separated at 110° to 120° showed less lipolysis than that separated at 75°. Cream from the centrifugal separator was less susceptible than gravity-separated cream.

Similarly, the Vermont station found that raw cream separated at 80° F. generally became rancid after storage while that obtained at 100° was much less susceptible to this defect.

Freezing as a method of preserving milk has recently been investigated to some extent. At the California station samples of pasteurized milk and cream, and also evaporated milk sealed in cans under partial vacuum, when quickly frozen and held for 6 weeks were found to be of good quality although slightly inferior to the fresh products in flavor. Raw milk similarly handled developed an oxidized flavor within 3 weeks. Concentration and freezing proved an effective means of preserving pasteurized homogenized fluid milk in experiments at the Pennsylvania station.

Butter production.—The fact that high mold content is now a basis for seizure of butter as unfit for interstate shipment has stimulated considerable work on means of preventing this defect. Findings of the Indiana station that butter produced from moldy cream generally contains a high content of mold mycelia, even though the organisms had been killed by effective pasteurization, have emphasized the necessity of attacking this problem from the standpoint of the prevention of mold growth in cream. Thorough sterilization of cream utensils and storage at temperatures below 60° combined with frequent agitation of the cream and delivery within 4 days were found to be effective measures that could be adopted on the farm for maintaining low mold content of cream. Studies at the Oklahoma, Arkansas, and Missouri stations essentially confirmed these findings.

The Iowa and Oregon stations agreed in finding that high temperature vacuum pasteurization of cream for buttermaking compares very favorably with the conventional holder pasteurization method. Both

flavor and body and texture scores of butter were higher under the former process, even in that derived from good-quality cream. The Oregon station reported that strong onion and pennycress flavors were largely eliminated by vacuum pasteurization, whereas vat pasteurization was ineffective. Similarly, the North Dakota station found vacuum pasteurization of cream to be the only effective method of removing Frenchweed flavors.

The Minnesota station has investigated various factors affecting and processes for improving the keeping quality of butter. Contaminated wash water proved to be a common source of infection of organisms causing cheesy or putrid butter. Chlorinating such water supplies did not always render them safe for buttermaking, and furthermore certain concentrations of chlorine in water imparted a disagreeable flavor to butter. Storing butter in a high carbon dioxide atmosphere did not materially reduce the rate of deterioration of butter as compared with a normal atmosphere. The beneficial effects of impregnating wrappers with salts of propionic acid in retarding mold development on butter have been more definitely established.

Cheese production.—In a study of factors affecting the rennet coagulation and curd tension of cheese milks, the New York State station found that the addition of lactic acid starter cultures or the development of lactic acid in normal milk decreased the time of coagulation and increased the curd tension. Setting rates and curd strength which had been impaired by excessive heat treatment could be restored to normal by the addition of calcium chloride.

A comparison of coverings for small Cheddar cheese prints at the Nebraska station gave evidence that from the standpoint of the flavor of the ripened cheese paraffin was preferable to parafilm, although the parafilm was the more effective in reducing loss of moisture. Regardless of the type of covering, cheese aged at 45° F. was of better quality than that aged at 65°.

Preliminary studies at the Pennsylvania station indicated that the addition of a small amount of calcium or sodium propionate to cheese curd was highly effective in preventing mold development in ripening Cheddar cheese.

The Wisconsin station demonstrated that the development of "early gas" in brick cheese could be entirely prevented by cooking the curd at a temperature of 120° F., whereas the defect was common when a cooking temperature of 106° was employed.

A technical contribution from the Washington station described the gas requirements of *Penicillium roqueforti* molds associated with blue cheese. Of particular significance is the fact that *P. roqueforti* proved more resistant to the inhibiting effect of CO_2 than other dairy molds. Using this information, a process involving a modified storage atmosphere for ripening Roquefort-type cheese in cans has been developed.

The Nebraska station demonstrated that a soft cheese possessing the flavor and texture characteristics of the conventional-type cream cheese could be prepared by combining cream, cottage cheese curd, and salt in such proportions as to give the desired fat and total solids content, and then heating the mixture to 180° F., homogenizing, and packaging. The Minnesota station found that marked improvement in quality of cream cheese resulted from homogenizing both the cream and the

cheese at the relatively high temperature and pressure of 175° and 4,000 pounds. It is recommended that the cream for cheese making be ripened to an acidity of 0.7 to 0.8 percent.

Ice-cream production.—Repeated tests at the Nebraska station have indicated that surplus skim milk could be advantageously used as a source of serum solids for ice-cream manufacture by condensing the product and holding in frozen storage until needed. Plain, superheated, and sweetened condensed skim milk all proved satisfactory for this purpose.

The preparation of an acid casein by precipitation of skim milk with diluted hydrochloric acid was found by the Texas station to give an inexpensive product that could be held in frozen storage and then redissolved for use in ice-cream mixes. Up to 40 percent of the serum-solids content in ice cream could satisfactorily be provided by this product.

In further investigations on the use of corn sweeteners as partial substitutes for sucrose in ice-cream manufacture, studies by the Missouri station indicated that ice creams containing 10 percent of sucrose and from 2 to 6 percent of either dextrose or cerelose were preferred to those containing 14 percent of sucrose alone. Enzyme-converted corn sirup was found by the Illinois station to have s weetening value of approximately two-thirds that of sucrose. When used to replace one-third of the sucrose in ice cream and one-half in sherbets and ices, this corn sweetener had no undesirable effect upon the frozen products. The New York State station found enzyme-converted corn sirup, corn sirup solids, and hydrated dextrose to possess a relative sweetness of 67, 49, and 89, respectively, with sucrose as 100. Best results were obtained by replacing 25 percent of the sucrose in ice cream or sherbets and ices with amounts of the corn sweeteners necessary to give the same sweetening equivalent.

Tests with ice-cream stabilizers by the Michigan station indicated that a prepared patented mixture of a monoglyceride and gelatin has definite advantages over gelatin alone, giving a frozen product of superior flavor and more compact body.

Studies at the Massachusetts station indicated that the amount of cocoa used in average chocolate milk, which approximates 1 percent by weight, does not significantly affect the digestibility of milk proteins.

Stickiness of the dried film and other difficulties encountered in the drying of whey on atmospheric drum dryers may be avoided, according to findings of the California station, by adding a small amount of skim milk solids to the whey either as fresh or condensed skim milk or spray-dried skim milk powder. Ground and sifted cereals also proved satisfactory for this purpose when added at the rate of 3 to 3.75 pounds per 100 pounds of whey.

GENETICS

Progress in the development of superior strains of livestock has resulted from a better and more complete understanding of heredity.

Studies of the inheritance of horns in sheep by the Kansas station suggested the operation of four pairs of factors, (1) *H* for horns, as contrasted with polled; (2) *hm*, a horn-modifying factor causing horned males and hornless females; (3) *Ih*, a horn inhibitor in both

sexes; and (4) *Sc*, a factor causing scurs. Homozygous dominants for the last character had longer scurs than heterozygotes, and animals with both recessive genes had no scurs. Following up this work, the California station suggested the operation of three factors in the multiple allel series. One dominant factor produces horns in both sexes, whereas the recessive produces horns only in the presence of the male sex hormone and another allelic condition produces hornlessness in both sexes. The scurs and knobs are assumed to result from interactions between these conditions and the effects of heterozygosis. In a comparison between Rambouillet and Corriedale sheep, the Texas station found that although Corriedale ewes produced heavier fleeces with less shrinkage than Rambouillets, the latter were about 16 pounds heavier at comparable ages and yielded more and heavier lambs.

Sex control.—Special interest centered in sex control in animals by modification of the acidity of the vagina prior to breeding. This theory was based on the production of females when the secretions were acid and the production of males when secretions were alkaline. Studies at the Illinois, Texas, and Wisconsin stations were contradictory as to support of the idea.

In fowls the Massachusetts station found a greater tendency for males than females to be produced in March-hatched chicks (51.24 percent males), whereas among April-hatched chicks there were 50.31 males.

Hereditary traits in poultry.—Investigations at several of the experiment stations have contributed to the identification of additional genes in the fowl. With progress in the discovery of new hereditary traits it should be possible to find out more about inheritance of characters of economic importance and how they may be associated in inheritance with other characters. The New York (Cornell) station discovered a gene for imperfect albinism in poultry which was inherited as a sex-linked recessive. This adds 1 gene to the 23 known in the 6 linkage groups and makes a total of 9 located in the sex chromosome.

A type of polydactyly called duplicate, involving the apparent doubling of parts of the foot and shank, was found by the same station to behave as a dominant gene.

Leg and foot feathering, such as occurs in Brahmas, was found by the Oklahoma station to be so closely linked with brachydactyly that there was only a small proportion of birds showing leg feathering which did not have short toes or reduced numbers of toes.

The Connecticut (Storrs) station noted that dwarf characteristics in the fowl may be caused by several conditions which may be classified in part as environmental and in part as hereditary.

Size factors in poultry were found by the Alabama station to be hereditary. In the second generation produced after crossing Dark Cornish fowls with White Leghorns, the Illinois station found significant negative correlations of large body size with low egg production. The correlated coefficient obtained was suggestive of linkage of the factors for size and egg production.

In a study of the broody periods of 1,767 Rhode Island Red hens, the Massachusetts station found that the degrees of broodiness depended on two complementary dominant non-sex-linked genes. The

number of times broody during the first year served as a reliable selection method for the occurrence of broodiness. Another study by this station showed that selection for egg production on less than 30 birds in each line was ineffective.

Inheritance of quality in eggs.—The California station found a single pair of allels with chalky dominant and modifying factors to be responsible for the glossy and chalky finishes of the shells of White Leghorn eggs. The same station found the percentage of firm albumen in the progeny of crosses to resemble the type of the dam's line more closely than that of the sire's line.

In a study of egg-weight variance in inbred fowls, the Iowa station calculated that 55 percent of the variance was genetic. At the same time the genetic portion was 74 percent as contrasted with 46 percent. As the degree of inbreeding increased over a 10-year period, the average egg weight decreased about 5 grams.

PHYSIOLOGY

Reproduction in domestic animals.—Differences in the estrogen concentration of the follicular fluid in the ovaries of mares of the Percheron, Belgian, and Shire breeds were found by the Missouri and Montana stations, in cooperation with the Department (B.A.I.), to be largely due to variations in the volume that could be collected, since the concentration was approximately identical at all stages. There were two peaks of estrogen production occurring during estrus, between the tenth and fifteenth days of the cycle. During pregnancy there was a marked increase in estrogen production as early as 30 days after conception.

Studies at the Missouri station, in cooperation with the Department (B.A.I.) and concerned with ewes, sows, cows, goats, and mares, showed that fertility of males was lowered by high temperatures, by too frequent services, and presumably by other environmental influences. Account must be taken in breeding operations of the variability in the duration of estrus and the optimum time for fertilization in ova of females of different species.

No correlation was noted at the Oregon and New York (Cornell) stations between the acidity of the vagina and breeding troubles in cattle.

Injections of estradiol benzoate into spayed yearling ewes at the Wisconsin station were found to induce heat within 1 to 2 days. The New York (Cornell) station found that ovulation in laying hens must occur from 25 to 40 minutes after laying.

Investigating the possibilities of producing antibodies to spermatozoa in fowls as a result of too frequent matings, the New York (Cornell) station found that injection of as much as 60 cubic centimeters of semen subcutaneously over a 10-week period did not cause an appreciable increase in the titer of agglutinins against spermatozoa. There was no evidence of increased infertility in frequently copulating hens, nor was it brought about as a result of intramuscular or percutaneous injections of testosterone propionate.

Studies at the Kansas station showed the body weights of dubbed cockerels to be about 15 percent greater and the weights of the testes twice as large as normal cockerels, but the male hormone recovered from the feces and testes of normal and dubbed cockerels after 4.5

months of age showed no significant differences. Histological development of the testes was similar.

Fertility and ascorbic acid.—Goats maintained at the North Carolina station on a diet inadequate for normal reproduction and lactation were found to contain 0.4 percent of ascorbic acid in the blood. This was approximately two-thirds of that found in the normal animal. Analyses also showed a similar decrease in the amount of ascorbic acid in the liver but not in the adrenal glands. There was a greater deposition of intraperitoneal fat in the experimental animals than in the controls, although the former had apparently lost weight.

Ascorbic acid was found by the Wisconsin station to show a close relationship to reproduction in cattle. Breed differences were noted, but a higher concentration was present in the plasma from mid- to late estrus than in diestrus. No differences were noted during the estrous period in good-to-poor breeders. After treatment with additional sources of this vitamin, beneficial effects were produced in more than half of the animals, indicating its possible value in treating certain types of sterility in cows. However, excessive amounts of ascorbic acid in the semen were often associated with unreliable breeding records. In this study α-tocopherol, the reproductive vitamin related to implantation of the fetus, was ineffective in restoring tone to a toneless uterus. At the same station, bulls of relatively low fertility subcutaneously treated with ascorbic acid showed increased fertility.

Preservation of viability of stored spermatozoa.—In chemical and physical studies, the New York (Cornell) station was able to maintain motility in some samples of bovine semen as long as 8 days with storage at 5° C. in the yolk-buffer pabulum developed by the Wisconsin station. Conceptions were obtained with semen samples stored as long as 4 to 5 days by this method. Fresh bull semen was found to be well buffered at pH 4 to 5.5 and 9 to 10 but poorly buffered at other degrees of acidity. The buffering action of one sample of seminal vesicle fluid was similar to the semen, but the buffering action of aged samples was reduced.

The Missouri station maintained fertility for artificial insemination in good-quality bull semen for 3 to 5 days when stored in an undiluted condition at 40° F. Further studies showed that a single sample of semen was not sufficient to indicate the fertility of a bull, three or more being recommended, and for rating at least five samples collected over not less than 2 weeks. It was possible in these studies to maintain motility longer in semen with a yolk-buffer diluent than in untreated samples. The egg yolk-buffer dilutor was effective in maintaining motility for 100 hours. However, good-quality semen survived longer when stored undiluted than when diluents were added. In studies at the Nebraska station there was the least change in viability and composition of bull semen stored at 35° F.

The Minnesota station investigated the significance of the sperm membrane of sheep as an indicator of sperm quality. The number of vesicles in the membrane over the anterior portion of the sperm head was reduced by aging and frequent ejaculation. A correlation of 0.7 was found between the number of vesicles present and the rate of glycolysis.

The Michigan station found that approximately 30 percent of chicken spermatozoa stored in a frozen condition maintained motility when

thawed at 42° to 45° C. 52 days after quick-freezing at −76°, but it was impossible to produce fertile eggs from such samples of semen. This temperature was the only one of several at which motility persisted longer than a few hours. Sucrose and levulose with and without physiological salt solutions were used for the diluents. It was also possible, in connection with this work, to produce a live chick from the use of semen which had been quick-frozen at 6° C. and thawed after 30 seconds.

Artificial insemination.—The Mississippi station perfected an improved artificial vagina for the collection of stallion and jack semen and for preserving it at 40° to 45° F. The sperm showed a high degree of motility. The best results were obtained when the sample was used on successive days, even when division was made in the same sample. This appeared to indicate the relationship of insemination to the time of ovulation. In the application of a chemical test for pregnancy in mares, the Michigan station found that tests were negative under 80 days after conception but usually positive results were obtained after 90 days. Electrical stimulation of ejaculation in rams was successfully performed at the Idaho station. After 22 inseminations of ewes with such semen samples, 16 conceptions resulted. An average of 2.83 inseminations were required per conception with dairy cattle.

Physiology of egg formation and reproduction.—A study by the Illinois station of the physical and chemical changes in eggs during their passage through the isthmus and in the oviduct showed that, in general, the weight of the yolk and its ash and solids content did not change while the egg passed through the isthmus and anterior uterus.

It was apparent from an investigation at the Kansas station that too-large and too-small egg size both depressed hatchability. Eggs having a proportion of white to yolk of 2:1 had a better chance to hatch than eggs with wider or narrower ratios.

The Kansas station studied eggs held in the oviduct for unusually long periods. These were found to have shells heavier than normal, but the shell percentages were reduced in eggs laid subsequently.

That the rate of laying was related to infertility was shown in studies at the New York (Cornell) station. The highest percentage of infertile eggs, 31.2, was in the eggs of hens laying at the rate of one egg per week, whereas the least infertility, 11.8 percent, was found in the eggs of hens averaging seven eggs per week.

DISEASES AND DISORDERS

HORSES

Parasites.—Internal parasites are now recognized as being responsible for many of the common disorders of horses. They contribute to the loss of efficiency in work stock since they are the cause of poor condition and lack of energy. In an attempt to ascertain effective methods for their control, the California station found that powdered phenothiazine fed mixed with the grain ration was very effective in removing strongyles from horses. The treatment was also effective in removing *Trichostrongylus axei* from colts, but ineffective against *Ascaris equorum* and *Gastrophilus* spp. No toxic effects were noted

in any cases following treatments at the rate of 45 grams of the drug for weanlings and yearlings and 70 or 80 grams for older horses.

On the other hand, the necessity of exercising care in treating horses for parasites is brought out in results reported from the Kentucky station. When a number of animals were treated with 950 cubic centimeters of a mixture consisting of oil of chenopodium, spirits of turpentine, and linseed and mineral oil, two developed very high fevers within a few days following treatment and died. It was concluded that administration of the drug to remove parasites caused a sufficient derangement of the intestinal tract to allow the paratyphoid organism to initiate a systemic infection.

Brucellosis.—In attempting to find the part played by horses in the spread of abortion in cattle, the Minnesota station made a bacteriological examination of the blood, urine, and feces of five horses that reacted to the agglutination test for *Brucella abortus* infection. The elimination of the organism with the feces led to the conclusion that horses may be a source of infection for cattle.

Equine encephalomyelitis.—Where outbreaks of this disease occur, mortalities and consequent economic losses are usually quite heavy. The Kansas station isolated the virus causing this disease from a bloodsucking conenose that occurs commonly over much of the region where the disease has appeared and is known to feed upon horses. This information, considered the first known evidence of the virus in a bloodsucking insect in nature, adds materially to knowledge of the disease and will be of assistance in developing measures for its control.

CATTLE

Anaplasmosis.—This is one of the serious diseases affecting cattle. Under certain conditions mortality is high. Recovered animals remain a constant source of infection without showing any outward symptoms of the condition. The Oklahoma station, in cooperation with the Department (B.A.I.), was unable to demonstrate hereditary survival of *Anaplasma marginale* (causative organism) in the eggs or larvae of the spotted fever tick. The station also observed that 16 in a herd of 747 3-year-old grade Brahman steers, whose horns had been tipped before shipment from Louisiana to Oklahoma, developed anaplasmosis, the first case appearing 42 days after the last date of tipping. Three of the animals succumbed to the affection.

Mastitis of dairy cattle.—Mastitis, because of its relation to public health, is probably the most serious disease problem facing dairymen at the present time. The Michigan station found that cows which had streptococci in the milk prior to slaughter also had the organisms in the udder tissue collected immediately after slaughter. The absence of streptococci in properly collected milk samples is considered evidence that streptococci infection was not present in the udder tissue.

The Washington station developed an apparatus which makes possible the rapid and relatively accurate determination of the electrical conductivity of milk. This conductivity has been found to be a good indicator of milk from abnormal quarters. Early cases of mastitis can be detected with a degree of accuracy comparable to that of the more time-consuming and complicated chemical or biological tests now in use. Radio earphones are worn by the operator, who

milks a stream into the machine which then is dialed to indicate the degree of electrical conductivity. Since the result is known immediately, opportunity is given to make a physical examination or to collect samples for confirmatory tests and to supervise such sanitary measures as may be deemed necessary.

At the Florida station it was observed that houseflies crawled or flew alternately from one teat orifice to another of the same or of different individual cows in the corrals or milking sheds. Controlled experiments showed conclusively that the housefly is a natural spreader of mastitis under the above conditions.

A study was undertaken at the Michigan station to determine what therapeutic effect sulfanilamide may have in acute and chronic cases of streptococcic mastitis. It was found to be very effective in relieving the symptom reaction in acute streptococcic mastitis, as indicated by the decrease in body temperature and the return of the cow's appetite. In the case of cows affected with chronic streptococcic mastitis, the number of streptococci eliminated in the milk decreased during treatment, but in all cases the numbers subsequently returned to the pretreatment levels. The drug appeared to be quite toxic for cows when administered in repeated large doses.

A practical and convenient method of destroying the mastitis streptococci on the hands of milkers and in the droplet of milk remaining at the end of the teat after milking, which is attractive to flies, is important in the control of bovine mastitis. Solutions of commercial soaps and soap powders at 40° C. and in the presence of 5 percent each of skim milk and broth culture of the organism were found by the Washington station to be between two and three times as effective as phenol in killing mastitis streptococci in 1 minute. The solutions were also as effective as 100 parts per million of the most actively germicidal of several hypochlorites tested. A soap containing cresols was no more germicidal and those containing mercury compounds only slightly more effective than were the nonmedicated soaps. A soft soap usually called "greensoap," tincture of green soap, and a coconut-oil-base liquid soap were found to be inferior germicides against this organism. Soap solutions in the concentrations usually obtained in lathering the hands with soap in warm water are effective disinfectants and may satisfactorily replace other disinfectants for the hands of the milkers and the teats of the cows.

Bang's disease (brucellosis or infectious abortion).—This disease, because of losses in calf crop, breeding difficulties, and relation to public health, is of significant economic importance. While practical control measures have been developed, many problems remain to be solved. In cooperation with the Department (B.A.I.), the Wisconsin station made carefully controlled tests of two widely used alleged remedies for Bang's disease, namely, 3–V Tonic and Bowman's. The animals treated with these two products, both before and after exposure to virulent *Brucella* organisms, became chronically affected with Bang's disease in the same manner and to about the same degree as untreated control animals.

The above agencies also made an investigation of the importance in the Bang's disease control program of cattle that, following infection, have lost their agglutination titer to *Brucella abortus* and are known as ceased reactors. With the exception of a transitory

infection in one quarter of the udder of a ceased reactor, *B. abortus* was not demonstrated in any of the cows by culture or guinea pig infection at the time of calving. None of the normal cows which were allowed to commingle with the ceased reactors showed evidence of having been infected by the reactors, except one individual, in the herd with the cow showing the transitory infection, whose serum showed a low titer for the organism. The results indicate that it is relatively safe to allow ceased reactors to Bang's disease to mingle with noninfected stock.

In studying the duration of immunity produced by calfhood vaccination with strain 19 of *Brucella abortus*, the Indiana station carried 13 animals through two gestation periods. Of these animals 9 were vaccinated when from 4 to 6 months of age and 4 were kept as controls. At the end of the first pregnancy the vaccinated animals delivered full-term living calves. The 4 controls also carried full-term calves, but 2 were born dead. Following exposures in the fifth and sixth month of the second pregnancy, 6 principals gave birth to full-term living calves. The other 3 principals delivered premature living calves, and *Br. abortus* was demonstrated in all three animals. All of the controls aborted in the second pregnancy.

The principal source of reinfection of herds once cleared of Bang's disease was found by the Connecticut (Storrs) station to be associated with infected animals, either as the result of adding cows or bulls from untested or infected herds or of animals breaking into or out of pastures. Association with infected horses or swine accounted for several "breaks," and in some instances available evidence indicated that infection resulted when people went directly from infected to negative herds. In about half of the reinfected herds, regular 6-month retests detected new infection before it had a chance to spread to more than one or two animals.

Parasites.—The control of internal parasites is essential to the health and well-being of cattle. The Louisiana station observed immunity in 3 calves to a mixed infection of nodular worms and hookworms that was induced by previous infection, also immunity in 1 calf to a pure infection of nodular worms. The development of the immune reaction was not associated with the age of the host, the length of the infection period, or the degree of infection. That the resistance was not permanent, however, was indicated by the fact that 1 individual acquired a much higher infection after 5 months under nonexperimental conditions than under controlled conditions.

Experiments at the Hawaii station led to the conclusion that liver fluke in cattle may be best combated through control of the snail carrier *Fossaria ollula*, a common inhabitant of fresh-water streams and swamps. Such a program includes the prevention of grazing in swamps or the feeding on grass cut from these areas and the treatment of infected animals. The snail may be controlled (1) by broadcasting copper sulfate at the rate of 20 pounds per acre, using 1 part of the chemical to 4 parts of a carrier such as sand; (2) by application of copper sulfate in streams at the rate of 1 to 200,000 or 1 to 300,000 parts of water; or (3) by drainage of swampy areas. Cattle may be protected from infection by fencing off areas where drainage is not practical and allowing cattle to feed only on vegetation from dry areas. The drugs distol and kamala have been found effective in most instances in the removal of flukes in cattle.

Trichomoniasis in dairy cattle.—During the 8 years of observation of this disease at the Utah station, 506.5 months of production were lost in temporarily and permanently sterile heifers. The cows during the same period lost 293.5 months of production, the economic loss of which was partially overcome by extended lactation periods. The results indicated that in the female the uterus is the primary site of infection of the causative organism, *Trichomonas foetus*. During a 3-year period a total of 18 cases of infection in females and 2 cases in bulls were found. Ten of the females made complete recoveries. This suggests that to a certain extent trichomoniasis of the cow is a self-limiting disease.

Calf pneumonia.—Broncho-pneumonia in young animals, known also as septic pneumonia, causes heavy losses among dairy calves confined in crowded insanitary lots. Such conditions, the Florida station found, are favorable to development of various bacterial infections of the gastrointestinal tract and the umbilicus, and to infestations with external and internal parasites. These parasites lower the body resistance of calves sufficiently to permit the micro-organisms colonizing in the respiratory passage to exert a pathogenic action resulting in development of broncho-pneumonia. The disease was not found on premises where strict sanitary methods of rearing calves were used.

SWINE

Swine erysipelas.—During the past several years it has become apparent that erysipelas is a permanently established disease in certain swine-producing areas and one of great economic importance. In cooperation with the Department (B.A.I.), the Nebraska station has been successfully using the serum-virulent culture method for protecting swine against this disease.

The Washington station undertook a study to determine what disinfectants could be used for eradicating the infection from premises following an outbreak, and which materials provided the greatest margin of safety when used on the hands following exposure to the organism. The results of this study show that the causative organism (*Erysipelothrix rhusiopathiae*) is readily destroyed by household lye (sodium hydroxide) and the hypochlorites. Where it can be used, household lye is the most practical disinfectant. The organism was resistant to formaldehyde, hydrogen peroxide, alcohol, and salt brines.

The Idaho station found that the disease can be eliminated from a swine herd by drastic culling of reactor individuals together with other sanitary procedures. It appeared that, by culling and disinfecting navels of newborn pigs and by employing a sanitary grazing system, this disease can be eradicated.

Hog cholera.—This disease has been recognized as a threat to the swine raiser for many years. While satisfactory means of control have been worked out, improvements in methods are constantly being sought. The Ohio station has found that through the use of crystal-violet vaccine satisfactory immunity can be produced in pigs from sows that either have or have not been serum-virus treated, provided the pigs from the treated sows have been weaned a sufficient length of time prior to vaccine administration. Hog cholera was not

transmitted by vaccine-treated pigs to susceptible pen associates. Immunity was usually satisfactory in tests made 30 days after vaccination, but was not so uniformly complete when tests were made at 2 to 3 months following vaccine treatment. Crystal-violet vaccine is expected to be more economical than the established serum-virus treatment and avoids the use of a live virus, offering possibilities of the vaccine as a method of disease eradication rather than a disease preventive, as is the case with the serum-virus treatment.

At the North Dakota station a study was undertaken to determine whether anemic pigs nursing immune sows are more susceptible to hog cholera than litter mates which are not anemic. It was concluded that development of pig anemia did not destroy the passive immunity received from the sows.

Toxicity of spray residues.—The possible hazard of lead arsenate poisoning as a result of feeding moderate amounts of sprayed fruit is of economic importance to orchardists and to swine raisers in those regions where apples and pears are raised commercially. At the Washington station lead arsenate spray residue, containing 1.47 grams of arsenic and 3.2 grams of lead and equivalent to the consumption of 7.2 pounds of apples carrying an average residue of 0.205 gram of arsenic trioxide and 0.445 gram of lead per pound, when fed daily for 140 days to a pig weighing between 101 and 165 pounds had no detectable effect. These results suggest that the arsenic and the lead which remain on apples as spray residue are relatively nontoxic to swine.

SHEEP

Plant poisons.—Under certain conditions poisonous plants become a serious problem to sheepmen. The Texas station, in cooperation with the Department (B.A.I.), reports the poisoning of sheep, goats, and cattle from feeding on the buds and blooms of sacahuiste (*Nolina texana*), a plant relatively common on the ranges of western Texas. When these parts of the plants are consumed by sheep and goats in amounts greater than 1 percent of their body weight, the animals become sick and usually die. If only dry feed is available at this time they will be very much depressed and a marked degeneration of the liver cells will occur, accompanied by obstruction of the bile duct. If some green feed is consumed at the same time the animals also become photosensitive, and if they are exposed to the sun will develop itching of the skin and marked swelling of the skin and subcutaneous tissue of the head, including the ears. It has been found that losses from this source may be prevented by removing the animals from infested pasture during the blooming season, by concentrating them on a smaller area in the pasture, or by removing them to the less heavily infested areas so that they will not be able to consume a toxic dose during a day's grazing.

Internal parasites.—Means of reducing or eliminating internal parasites constitute one of the most significant management problems of the sheep producer. The Kansas station treated a few lambs heavily infected with stomach and nodular worms with a single dose (0.5 gram per pound of body weight) of phenothiazine solution, consisting of phenothiazine 10 grams, powdered acacia 0 5 gram, and water to make 30 cubic centimeters. This treatment reduced the eggs per gram of feces count to a harmless level in all cases. Under the same con-

ditions a solution consisting of 1.7 percent copper sulfate and 1.7 percent nicotine sulfate failed to reduce the count in one animal to a nonsignificant level.

Toxicity of spray residues.—Occasional reports received by the Washington station of the illness or death of livestock, principally cattle and sheep, that had been pastured in sprayed orchards during the fall led to studies of the condition. Nine sheep were fed lead arsenate orally in capsules in amounts varying from 0.25 gram to 2 grams per day. Animals receiving 1 or 2 grams per day died within a few days, in most cases after having received about 1.5 grams of arsenic, an amount which appears to be approximately a lethal dose when fed in small amounts daily. Analytical results of stomach contents, a number of organs, and of urine and feces did not account for all the lead and arsenic consumed. A large proportion of the lead and arsenic remaining in the body was found in the stomach contents. Small amounts of these elements were found in the liver, kidney, heart, lungs, gall bladder, bones and marrow, and wool. The darkening of the bone marrow observed in some of the lead arsenate-fed sheep supports the suspicion that the feeding of arsenic-containing compounds may be responsible for the condition known as "black cutters."

POULTRY

Fowl paralysis.—This disease has been responsible for tremendous yearly losses to the poultrymen of this country. The Idaho station reported ready transmission to young chicks by contact. Chicks from susceptible stock contracted the disease regardless of attempts to isolate them on the premises where paralysis-affected stock existed. Pullets from paralysis-susceptible stock showed a distinct age resistance when not introduced before 6 weeks of age to premises now or recently occupied by affected stock. Certain families were more resistant than others to the disease. A high degree of resistance to fowl paralysis has been developed through intensive selection. The progeny of hens were more resistant to the disease than the progeny of pullets in the same affected flock. Confined rearing did not reduce the occurrence of the disease below that attained by range rearing.

Parasites.—Parasites are responsible for both direct and indirect losses in poultry. The Hawaii station found that the cecal fluke *Postharmostomum gallinum* is especially common in birds raised on the ground in areas where land snails (*Eulota similaris* and *Subulina octoma*) occur.

The Washington station fed phenothiazine to birds suffering from a natural heavy infestation of cecal worms. The drug was given either in the feed or in hard gelatin capsules, both single and repeated doses being tested. The average effectiveness was between 95 and 100 percent, both from the standpoint of cecal worms expelled and killed. Individual capsule medication had no appreciable effect on egg production of a flock, and neither massive nor therapeutic doses had any effect upon the flavor of the meat. The administration of phenothiazine was not followed by enteritis or other digestive disturbances.

Each of the four grades of sulfur tested at the Louisiana station, namely, flowers of sulfur, commercial flour sulfur, 325-mesh sulfur,

and micronized sulfur, had value in preventing coccidiosis mortality in chickens. There were indications that of the ground crude sulfurs, the finer the grind the greater the efficiency. Commercial flour sulfur retarded growth less than other forms of sulfur but gave the least protection from coccidiosis. Regardless of the kind or amount of sulfur fed, chicks inoculated with coccidia produced oocysts which were viable, would sporulate, and produced clinical evidence of the disease.

Fowl pox.—This disease is especially serious in young chickens, affecting their normal development even though the mortality rate may be low. In studying fowl pox immunization, the Illinois station found that potent fowl pox and pigeon pox vaccines properly administered to healthy fowls produce a measurable immunity against fowl pox. The immunity induced by the application of fowl pox vaccine, stick method, is of longer duration and better defined than the immunity induced by the application of pigeon pox vaccine by the feather-follicle method. On contaminated premises vaccination of chickens 4 to 8 weeks old is recommended.

GENERAL

The action of soil micro-organisms against bacteria.—The New Jersey station studied the effect of two organisms belonging to the *Pseudomonas aeruginosa* and *Actinomyces* group on bacteria. The active substance produced by the two organisms was found to be largely thermostable. Highly active preparations were obtained which inhibited, in very dilute solutions, the growth of *Escherichia coli*, *Brucella abortus*, and many other bacteria. The active substance had also a strong bactericidal effect upon *E. coli* and *Br. abortus*. This substance reduced, in very low concentrations, the bacterial population of natural substrates, such as milk. When added to agar it prevented the development of the great majority of soil bacteria and actinomycetes but not of fungi.

Oat-hay poisoning.—Many cases of poisoning resulting from the ingestion of oat hay and straw, largely by cattle, have been reported in Wyoming during the past 5 years. The Wyoming station found high concentrations of saltpeter (potassium nitrate) to be the cause of the poisonous property of hay and straw. Methylene blue in doses of 2 grams per 500 pounds of animal, injected intravenously, immediately counteracts the effect of the ingested nitrate. Other plants, such as wheat, barley, sorghums, corn, and weeds, may sometimes contain enough nitrate to be poisonous. The concentration of nitrate in the soil is one factor which determines the amount of nitrate in the plants.

Poisonous plants.—Poisonous plants are a constant source of trouble to livestock producers. In cooperation with the Department (B.A.I.), the Texas station made an investigation of sheep and cattle losses resulting from grazing on red-stemmed pea vine, an annual plant of common occurrence in southwest Texas. The plant is poisonous to cattle, sheep, and goats, the young plant being more toxic than when more mature. The characteristic symptoms were muscular incoordination and loss of weight with slow and difficult recovery. In sheep, difficult respiration also was observed. Plants collected from three limestone areas were found to be toxic in all

cases, but those collected from soil of igneous origin produced no toxic effects when fed to goats. The toxic principle was destroyed by drying the plant for 4 months.

Wheat screenings containing nutlets of *Amsinckia intermedia*, a plant which grows abundantly in grainfields in certain semiarid regions of Washington, Oregon, and Idaho, were found by the Washington station to be toxic to the pigs, horses, and calves to which they were fed. In cattle and swine the condition is known as hard liver, in horses as walking disease because of their tendency to wander aimlessly. It is probable that sublethal poisoning is much more widespread than is commonly recognized.

RURAL SOCIAL SCIENCE

CONTENTS

The increasing emphasis being placed upon the technical phases of soil conservation, crop adjustment, and other improvements in land use is reflected in the research currently reported in agricultural economics and rural sociology at the State experiment stations.

Much of the research of the stations during the year, as in the past, was done in cooperation with the Bureau of Agricultural Economics, the Soil Conservation Service, the Bureau of Plant Industry, the Forest Service, and other bureaus and agencies of this and other Departments of the Government. The following items have been selected to illustrate the lines of investigation undertaken by the stations in agricultural economics and rural sociology.

AGRICULTURAL ECONOMICS

SOIL CONSERVATION

An analysis by the South Carolina station, in cooperation with the Department (S.C.S.), of data obtained in surveys in 1935 and 1939 for 107 farms in the Little Beaverdam Creek area showed that the most important changes during the period were an increase of 100 pounds per acre in average lint-cotton production, a slight increase in labor efficiency, and a $100 increase in average labor income, of which 75 percent resulted from higher Government payments. The average labor income on the farms under agreement with the Soil Conservation Service was $502 as compared with $369 on those not under agreement.

In a study by the West Virginia station in cooperation with the Department (S.C.S. and B.A.E.) of 1935 and 1937 records for approximately 200 farms in the Harrison area of the State, it was found

that the income for many small general and self-sufficing farms is so limited that exploitation of resources is necessary; and that for conservation to be feasible, extensive commercial enterprises must be abandoned and income increased by growing commodities requiring less land and more labor per unit of output. The major need on many large beef-cattle farms was pasture and meadow land improvement to make possible the maintenance of the maximum number of animal units per acre.

A study in Franklin and Wilson Counties, N. C., made by the North Carolina station in cooperation with the Department (S.C.S., A.A.A., and B.A.E.), showed over two-thirds of the total cultivated land in Franklin County and about 80 percent in Wilson County in row crops. In Franklin County, less than 1 acre out of 8 was in legumes and only about 30 percent of the legumes were plowed under for soil improvement. Only about one-third of the land in corn and one-tenth of that in cotton were fertilized at planting time, and the parts fertilized received only one-third to one-half of the amounts of fertilizer recommended by the station. More than 80 percent of the total land area was found to have lost much of its fertile topsoil and there has been little erosion control. In Wilson County, only about 10 percent of the cropped acreage was in legumes, and in only about 1 acre in 24 had legumes been plowed under for soil improvement. Only an average of 1 acre in 175 was limed annually.

LAND USE

In a study by the South Dakota station, in cooperation with the Department (B.A.E.), in Hyde County, the conclusion was reached that under ranch conditions approximately 2,560 acres are needed to support a family. Where extensive farming (about one-third of the land in crops) is practiced, 960 acres is the minimum, and with intensive farming (about 45 percent of the land in crops) 640 to 480 acres.

A study by the Oregon station, in cooperation with the Department (B.A.E.), was made of the range organization and range land use on an experimental tract in Coos and Curry Counties, selected by the Oregon State Land Use Committee. The carrying capacity of the ranches averaged 1.7 acres for sheep and 11.6 acres for cattle. The labor income averaged $2.47 per sheep on sheep ranches and $5.11 per head of cattle on cattle ranches. The returns on investment (net income minus $600 for wages of operator and his family) were 9.7 percent for sheep, 4.8 percent for beef-cattle, 5.4 for dairy-cattle, and 9.4 percent for mixed cattle and sheep ranches, exclusive of the rental value of the farm home and the value of farm produce used in the home.

Studies were completed on types of farming and land utilization in Alabama and Maryland, in cooperation with the Department (B.A.E.), by the stations of these two States; in New Castle County, Del., by the Delaware station; and in Providence County, R. I., by the Rhode Island station.

Irrigated lands.—Land ownership and tenure on the Huntley project of the Bureau of Reclamation of the Department of the Interior was studied by the Montana station. The entry unit on the project was 40 acres, but by 1936 approximately one-third of the

farms included 21 to 60 acres, one-third 61 to 100 acres, and one-third over 100 acres. The owners had 48 percent of their available acreage in soil-conserving crops, compared with 43 and 41 percent, respectively, for tenants and owner-renters.

A study of the Yakima-Tieton irrigation district in Washington by the station of that State in cooperation with the Department (B.A.E.) showed that among the adjustments needed are consolidation and enlargement of farms, adjustment of land values to income-producing capacities, and diversification of land use. Another study by the same agencies of the production of dry peas in the Palouse area of Washington and Idaho showed that for most years pea production was profitable as an alternate to summer fallowing for wheat, but that a cash-crop wheat- and pea-farming system results in soil deterioration, especially soil erosion. The production of peas for seed and human consumption only would probably permit adequate soil conservation, but to conserve the soil and provide for prospective market outlets for peas the pea acreage should not exceed one-sixth of the crop land.

FARM AND LABOR INCOME

Labor income.—The effects of six farm-management factors—livestock efficiency, crop yields, size of farm, labor efficiency, amount of livestock, and intensity of crops—on labor income were studied by the Indiana station for approximately 50 farmers in the northwestern part of the State each year from 1929 to 1938. The average labor incomes for the different years varied from −$649 to $1,811, averaging $604 for the period. Where none or only one of the factors was above the average, the average labor income was −$67; where two, $310; where three, $692; where four, $1,386; and where five or all, $1,624.

Farm financial reports for farms in the central part of the State covering the years 1930–39 were analyzed by the South Dakota station. The average annual operator's earnings (labor income plus value of farm products used minus unpaid family labor) for the period 1932–39 was $320 for the 10 highest-income farms and −$1,118 for the 10 lowest-income farms. The high-income farms were considerably larger; had larger crop acreages, more productive animal units per acre, more equipment per acre, a smaller percentage of investment in real estate and a larger percentage in working capital, higher crop yields, and higher livestock-production efficiency; handled more crop acres and animal units per man; and carried larger reserves of grain, roughage, and cash.

A study by the Louisiana station of farms growing tomatoes in the northern part of the State showed that the average return was 25.4 cents per hour of labor spent on tomatoes. In general, the costs were $21 per 1,000 plants where less than 4,000 plants were set per farm, and $16 where 6,000 or more plants were set. The net gain per 1,000 plants varied from about $8 for farmers with small tomato enterprises to $16 for those with relatively large-sized units. The same station made a study of the relation of acres in strawberries, yield per acre, type of cultivation, prices, and other factors affecting the cost of production, and returns from strawberries in two sections of the Tangipahoa Parish area of the State.

Size of business, tobacco yields, and net livestock receipts per productive animal unit were found by the Kentucky station to be the principal factors affecting the variations in labor income on farms studied in the northern and central parts of Robertson County. The most satisfactory incomes were on farms large enough to develop a farming system requiring from 300 to 500 productive-man-work units per year.

The New York (Cornell) station showed that for 100 dairy farms in Onondago County in 1938 and 70 farms in 1939 the increases in labor income in the 2 years, respectively, due to different factors were: One productive-man-work unit, 90 cents and $1.29; one cow, $32 and $44; one point in crop index, $13 and $10; 100 pounds of milk per cow, $18 and $14; and one productive-man-work unit per man, $8 and $6. A decrease of a year in the time required for receipts to equal capital invested resulted in an increase of $448 and $422, respectively, in labor income for the 2 years.

The average labor income in 1939 on the 5 highest- and 5 lowest-income farms of 107 farms in the Little Beaverdam Creek area of South Carolina, studied by the station of that State in cooperation with the Department (S.C.S.), were $2,786 and −$522, respectively. The capital investment was nearly the same in both groups, but average acreage in farms, acres cropped, production indexes, and number of work units were 268, 162, 115, and 216 on the high-income farms and 137, 71, 99, and 174 on the low-income farms.

MARKETING

Fruits and vegetables.—The Missouri station studied the organizations and costs in the St. Louis wholesale fruit and vegetable market. The Indiana station made a study of the prices and receipts of fruits and vegetables on the Terre Haute, Ind., producers' market during a full market season (1937). The Tennessee station studied the facilities, supply of products, regulations, etc., of the Knoxville wholesale fruit and vegetable market, and also the marketing of field seed in the Knoxville area.

The Pennsylvania station studied packaging problems of eastern apple growers, showing that 1⅛- and 1⅕-bushel boxes do not contain one-eighth and one-fifth more apples than bushel baskets and that the variations in the packs by individual growers in a container are frequently greater than those between different growers. The New Hampshire station completed a study of the markets for and prices of New Hampshire berries.

The New Mexico station published findings in a study of market outlets for New Mexico onions. To cover present marketing costs on rail shipments from Las Cruces and Albuquerque, a selling price of 90 cents per 50-pound sack would be required at Chicago and $1 at Cincinnati. On shipments from Roswell, selling prices of 68 cents and 85 cents were required in the two markets.

A truckload of sweetpotatoes followed by the Maryland station from the packing shed in Maryland to the consumers in New York City showed that the losses amount to about 5 pounds per bushel in transit and on the wholesale and jobbing markets and to about 10 pounds in retail markets.

A study of country fruit and vegetable auctions in the eastern seaboard States by the New York (Cornell) station in cooperation with the Department (F.C.A.) showed that the chances of success of such markets were greater when a large volume of relatively perishable products are available, where there is no competing auction closer than 15 miles, where the period of operation is restricted to a season during which a large volume of fruits and vegetables may be handled daily, where there is a minimum investment in physical equipment, and where maximum use can be made of hired personnel.

Milk.—The New Hampshire station, using the number of commercial routes and self-haulers, the mileage of the routes, and the cost of hauling in June 1937 as a basis, outlined three schemes for reorganizing the milk routes of the State. The first was on the assumption that producer-dealer relationships would be undisturbed and that only the producers whose milk is hauled on commercial routes would participate; the second required all milk to be handled on commercial routes; and the third would include a relocation of the milkshed boundaries. It was found that the respective relative costs of hauling under the three plans would be 88.5, 76.2, and 73.3 percent of the cost in 1937. With the relocation of the milkshed boundaries, the reduction in the cost of assembling milk would amount to from $30,000 to $35,000 per year for the State.

Livestock auctions.—A study was made by the Minnesota station of the development; volume, character, and season of business; organization; operation; kinds of services; and charges of livestock markets in the State. During 1938, 22 of the auctions handled over 159,400 animals. Over 52 percent of the animals were sold by farmers, over 39 percent by dealers, and over 8 percent by auction operators. Farmers purchased over 61 percent, dealers over 37 percent, and auction operators over 1 pecent.

COSTS OF PRODUCTION

Cost-of-production studies of different crops, different types of livestock, and livestock products were carried on by most of the stations either as independent studies or in connection with conservation and land use studies. The average costs per acre for growing, harvesting, and marketing canning-factory tomatoes were found by the Indiana station to be $61.09 in the central part of the State, $52.18 in the northwestern part, and from $38.13 to $46.50 in different areas in the southern part of the State. The returns per hour of operator and family labor were 71, 28, and from 6 to 31 cents in the respective areas. Man labor constituted 35 to 46 percent of the total costs of growing and harvesting.

The Maryland station found that the cost of producing and marketing sweetpotatoes was $109.39 per acre. Labor constituted about 25 percent of the total cost of production, fertilizers 25, and packaging 20 to 25 percent.

A study by the Michigan station, covering the period 1933–36, showed the average cost of producing sugar beets to be about $39 per acre on farms producing approximately 10 tons per acre and the cost of marketing $9 per acre. The total returns were about $70 per acre. Of the total cost of production and marketing, hand labor comprised about 33 percent, growers' labor and use of machinery 18

percent, land use 16, other production costs 15, and marketing 18 percent. Growers with yields of approximately 6.5 tons per acre had a production cost of $5.74 per ton as compared with $3.21 for the growers averaging 13 tons per acre. The net returns per acre were more than 10 times as large with the 13-ton production.

PRICES

Price indexes.—Indexes of prices of farm products for their respective States were prepared by the Louisiana, Kentucky, North Carolina, North Dakota, and Delaware stations.

Tobacco.—A study of the seasonal movement of prices and sales of burley tobacco by the Kentucky station showed that the length of the marketing season has been shortened about 60 percent in the last 30 years, the opening being 3 or 4 weeks later and the closing 8 to 10 weeks earlier. Nearly 40 percent of the tobacco is now sold in the first quarter of the marketing season. The long-time trends in the seasonal changes in sales and prices were found to be due to improved transportation facilities, increased market capacity, increased competition, changes in type of tobacco, and the cumulative effect of high prices early in the season.

Milk.—As a part of the series of studies being made by the Department (B.A.E.) in cooperation with different State stations, the Michigan station made a study to obtain information as to the long-time outlook for dairying in the State and the adjustments that will be desirable under different conditions. On the basis of the analysis of farm-business records of farms in Lenawee and Mecosta Counties, it is estimated that the production in 1946 in the two areas and in the State as a whole will be 114, 116, and 115 percent, respectively, of the 1936 production if there is no change in the price relationship of milk and other farm products. If the price of milk relative to that of other farm products increases 20 percent, the estimated production will be 124, 128, and 125 percent, and with relative price of milk 20 percent lower, the estimated percentages will be 103, 111, and 107, respectively.

TAXATION

Tax delinquency.—The total unpaid property taxes in Montana on June 30, 1939, amounted to 8.2 percent of the total taxable valuation of the State, according to a study by the Montana station. This percentage was nearly twice as great as in 1932 and four times as large as in 1920. The amount of the unpaid taxes on property carried on the current tax rolls was equivalent to a 56-mill levy on the total assessed valuation in the State. The area subject to tax deed and already owned by counties comprised 17 percent of the total taxable area. The Oregon station also published data on the relative percentages of delinquency on different types of land in different areas of the State.

Assessments.—A study by the Maryland station of the ratios of assessed to sale values during the period 1933–35 in 7 counties of the State showed a range of 81 to 132 percent, average 99, for bona fide voluntary sales; 98 to 179 percent, average 137, for administrator, executor, and assignor sales; and 105 to 172 percent, average 142, for foreclosures and other distress sales. Individual ratios for 807

bona fide sales varied from 15 to 603 percent. Farms with a sale value of less than $20 per acre were assessed at rates giving nearly twice the ratio of those valued at $80 or more per acre.

State aid and rural property taxes.—Outstanding facts brought out by a Wisconsin station study of the effects of the State aid on the tax levies on property in three representative counties were that, while the aggregate cost of local government in the counties had increased greatly, the total property levies had decreased owing to aid from the State and Federal Government. While the expense of local government had been higher than it would have been without State and Federal aid, much of the increase was due to greater services, such as better roads, better schools, and more pensions and relief.

CREDIT

Real-estate indebtedness.—A study by the Illinois station of 827 first-mortgage loans made in the State between 1917 and 1933 brought out the fact that on April 1, 1936, 14 percent had been paid, the interest and principal payments had been met on 52 percent, loan extensions had been made on 17 percent, 4 percent were delinquent, and 13 percent had been foreclosed or voluntary transfers made to the lenders. It is stated that the following conclusions on loan risks may be drawn:

(1) The higher the loan in relation to the appraised value of the land, the greater the likelihood of foreclosure.
(2) Losses to lenders are likely to be heavier on poor soils than on good soils.
(3) Under conditions like those in east-central Illinois, loans on rolling land are more hazardous than those on more level land, because of the greater difficulty of controlling erosion on the rolling land.
(4) Difficulties with loans are particularly likely to develop in border areas between good and poor land.

A study by the Montana station brought out the fact that on July 1, 1940, over 41 percent of the farms of the State were mortgaged at an average of $6.02 per acre, or more than 75 percent of the average value reported by the United States census. The average loans were 87 percent of the average productivity value of the lands.

Short-time credit.—Studies of the short-time credit used in 1938 were made by the Arkansas station in Ashley and Hempstead Counties. The average cost in Hempstead County to small owners was 10.4 percent, to plantation owners 5, and to tenants 15.3 percent. The average percentage of loans delinquent on December 31, 1938, by sources of credit, were banks 4 percent, production credit associations 4.5, merchants 38.1, Farm Security Administration 84.6, and others 27 percent, averaging 26.3 percent for all loans. In Ashley County, the average cost to small owners was 12.8 percent, to plantation owners 8.4, and to tenants 17.6 percent. Nearly 31 percent of the loans were delinquent on December 31, 1938. The New York (Cornell) station also was engaged in a study of sources, costs, and terms of short-time loans from banks and production credit associations; the possibilities and extent of shifts of loans between agencies; and methods of effectively and economically granting and collecting loans. A study was in progress at the Maryland station on farm

credit in the lower Eastern Shore area, and an analysis was being made by the Minnesota station of the operation policies and the results in active and closed banks.

COOPERATION

Cooperative purchasing.—The West Virginia station studied and made suggestions for the improvement of the organization, operating set-up, operating practices, and financial policies of the West Virginia Farm Bureau Service Company. Preliminary findings in a study in progress at the New Hampshire station showed that a saving of $1 to $3 per ton is possible by purchasing feed in advance so that delivery can be made direct from cars, and that 10 to 30 percent can be saved by advance orders for machinery so that orders may be grouped.

Cooperative oil associations.—A study by the Nebraska station in cooperation with the Bank for Cooperatives of Omaha (F.C.A.) showed that during the period 1935–38 14 percent of the petroleum business of the State was handled by cooperative associations. The average costs of operation for 1937 and 1938 for the cooperative service stations were 2.66 cents per petroleum unit where less than 200,000 units per year were handled, 2.2 cents with 300,000 to 399,000 units, and 2.69 cents where 600,000 or more units were handled. The cost for bulk plants ranged from 2.01 cents for the group selling 200,000 to 299,000 units to 2.49 cents for those selling less than 200,000 units. Expenses were 16 cents per dollar of sales by service stations where less than 10 percent of the sales were on credit and 20 cents where 20 percent or more of the sales were credit sales. A study of 92 associations by the Minnesota station showed that the net income in 1939 averaged 6.39 percent of the sales, ranging from a loss of 4.14 percent to a profit of 13.39 percent. The 20 associations with the highest returns had larger sales, higher gross margins, and lower operating expenses per dollar of sales.

Fire insurance.—A study of 27 mutual fire insurance companies by the North Carolina station in cooperation with the Department (F.C.A.) showed that the average assessments in 1938 per $100 of insurance were 35.5 cents, the average losses 17.2 cents, and the ratio of losses to disbursements (1937) 71.5 percent. Expenses per $100 of insurance declined as the size of business increased up to $1,500,000 but losses increased. The West Virginia station, on the basis of a similar study in that State, suggested that farmers' mutual insurance companies give consideration to extending protection to other types of property than buildings, to better acquainting policy holders and potential policy holders with the need for protection, to adopting uniform rate classifications and uniform charges for comparable risks, to methods of collecting premiums or assessments, to building up adequate reserves, to adopting uniform policies, to developing better arrangements for reinsurance and concurrent insurance, to providing better risk inspection, to preventing unnecessary duplication of cost and effort resulting from duplication of territories by companies, and to keeping directors and policyholders acquainted with the problems confronting their companies. A study in progress at the New York (Cornell) station has already resulted in the revision by a number of

companies of the rates for fire and lightning insurance to apportion more equitably the costs and thus reduce the expense to many farmers who do not have the more hazardous risks. A study was also in progress in Maryland.

Canning fruits and vegetables.—A study by the Oregon station in cooperation with the Department (F.C.A.) of cooperative canning associations showed that the average investment per member in 1938 ranged from $184.52 to $1,111.88, the investment per ton of produce handled from $7.65 to $73.64, and the investment per case of product from 45 cents to $1.48. Generally, patrons living more than 25 miles from the canning plant could not be satisfactorily served.

Farmers' elevators.—A study of farmers' elevators in the State by the Illinois station indicated that unless an elevator handles a minimum of 300,000 bushels of grain per year and is economically operated, additional functions and services besides receiving and shipping grain will be necessary to insure a profit. A large grain business and a substantial merchandising business was the best combination. Need of adjustment of operations to changed transportation methods and more attention to membership relations and methods of obtaining new members are pointed out as important matters to be considered by the companies. Studies of elevator companies are continuing in Iowa, Kansas, Ohio, and several other States.

Cotton gins.—Members of cooperative ginning associations will be able to save $1 to $3 per bale of cotton, according to a study by the New Mexico station of such associations in that State. In addition, the success of the cooperative gins has stimulated cooperative selling of both cotton and cottonseed with a resulting improvement in the net returns. An analysis of 1,200 cotton-gin records, covering the period 1930–31 to 1938–39, by the Texas station showed that 71 to 89 percent of the variations in the cost of ginning were due to volume of cotton ginned and the investment in the plants.

General studies of cooperative organizations were completed by the Alabama, Tennessee, and Virginia stations, and by the North Dakota station in cooperation with the Department (F.C.A.).

MISCELLANEOUS

Tenancy.—Studies in farm tenancy and farm leases were begun or continued by a number of the stations. The Georgia station in cooperation with the Department (B.A.E.) published a graphic summary of farm tenancy in that State, the Oklahoma station a bulletin on the legal aspects of landlord-tenant relationships in that State, and the Minnesota station a bulletin on farm tenancy in Minnesota. The Tennessee station also published on landlord and tenant relations in Roane County.

Truck transportation.—A study by the Indiana station of transportation of farm products by commercial truckers in the central part of the State showed that the average 1½-ton truck was driven over 24,000 miles per year at a cost of 4.2 cents per mile. Operators of one truck averaged 409 loads per year, traveled an average of 37 miles per trip, and carried an average load of 2.7 tons. Their average receipts were $5 per load and the average returns per hour of labor about 40 cents. Receipts per mile traveled for all operators averaged 9.1 cents and costs including labor 8 cents.

County receipts and expenditures.—A study was made by the Missouri station in cooperation with the Department (B.A.E.) of the land use and the financial and other problems of Reynolds County, representative of the rougher parts of the Ozark region of the State, with a view to aiding in the formulation of public policies directed toward solving the problems of the area. A study of cost of county government in New York was also being carried on by the New York (Cornell) station.

Among other types of investigation being carried on by the stations were studies of freezer-lockers, farm-management studies of low-income farms, studies of the effect of stripping land for coal and of surface and subsurface rights in oil fields on agricultural returns and taxation, studies of cotton improvement especially in one-variety commodities, and studies of labor saving in vegetable- and fruit-packing sheds.

RURAL SOCIOLOGY

Rural sociologists at the stations are participating increasingly in the analysis of practical problems confronting rural people. Their results, as here summarized in a much curtailed presentation, indicate the national interest in population studies and the social aspects of agricultural planning.

POPULATION STUDIES

In a study of the composition and movement of rural population, the Kansas station found that during 1939 the number of persons living on the farm increased, the birth rate increased slightly, and there was a decrease in the movement of persons to towns and cities.

The Washington station reported that the farm population of the State increased during the year 1939 from 361,100 to 367,300. The depression, which reached its climax in 1932 on farms, saw more movement to farms than to cities. Since that time the movement to cities has exceeded that to farms, but the net movement to cities has averaged less than half that which took place in the decade of the twenties. The North Dakota station, on the other hand, reported a decrease of approximately 61,000 in the number of persons on North Dakota farms since 1930, 49,000 of these since 1935. It is suggested that the high rate of natural increase plus the movement of persons from villages and cities and from out-of-State farms may result in North Dakota's having more farm people than can find opportunities on its farms. According to the Kentucky station, from 1930 to 1940 the net migration out of that State was only 2 percent of the 1930 population. The Alabama station reported that the movement of farm population to town is more evident in the lowland areas than in the upland. The average cash income of the itinerant migrant family approximated $450 and that of casual workers $300. The Colorado station reported that the State is approaching its population saturation point under its present economic and social structure. Agriculture cannot provide jobs for any significant future increase unless it becomes possible to increase the amount of water available for irrigation purposes and to develop more intensive farming.

The Arizona station, in its agricultural-population study of the State, reported that 40 percent of the heads of agricultural households came

from Southern States; 35 percent were born in Mexico; 7 percent came from other than Southern States; 3 percent were foreign born, from European or Oriental countries; and the remaining 15 percent were natives of Arizona. Of the farm owners at the beginning of the period, 83 percent were farm owners at the end of the period, 6 percent had become farm tenants, 7 percent had dropped back to the laborer stage, and 3.5 percent had gone into other occupations. Resident heads of agricultural households were for the most part geographically stable. The resident Mexican laborer population in Arizona contained the largest average number of persons per household, while the smallest numbers per household were found among the white farm-owner population. Rural-farm population in Arizona was strongly male, the sex ratio being 116 males to 100 females as compared with 111 to 100 for the United States.

An estimate of farm population, made as of January 1, 1940, by the Minnesota station, revealed a total farm population of 911,000, an increase of 1,600 over the estimate of the previous year. Marriage-license records of Scott and Carver Counties for the period 1929 to 1938 showed that propinquity of residence was an important factor in choice of marriage mates. Over 40 percent of the couples gave the same post-office address in the county. The Louisiana station found that, on the basis of age of people, farms have excessive proportions of children, too few persons of working age, and a slight excess of old persons. Urban centers have high proportions of persons in the aged class working, few children, and few old people. Villages have a slight scarcity of children, a marked scarcity of persons in the working ages, and exceedingly high percentages of old folks.

The Virginia station found that less than half of the Virginia farm boys are needed to maintain the number of farmers at a stationary level and that relatively few of the youth not needed on farms are receiving much specific training for other types of work. Negro youth apparently have a growing desire to get away from the land. The station also reported that 61 percent of the population of Southampton County are Negroes, 80 percent of whom are tenant farmers. Between 1910 and 1935, the number of Negro tenants increased 26 percent as compared with a decrease of 21 percent in the number of owners and a decrease from 34,000 to 27,358 acres in Negro land holdings.

SOCIAL IMPLICATIONS OF TENANCY

The Tennessee station reported that of southern white farmers who began farming as renters, 38 percent have raised their tenure level to farm ownership. Factors aiding tenants to become owners are low land values, greater tenant effort, increasing accumulation of resources, aid by landlords, and aid by Federal and other farm agencies.

The Oklahoma station found that the rate of increase in farm tenancy has slowed down in recent years, indicating that the proportion of farms operated by tenants is nearing or has already reached its peak. The birth rate was found to be 23.3, while the death rate was only 8.2, per thousand.

RESETTLEMENT OF FARM FAMILIES

The Washington station reported on settlement of cut-over lands in western Washington, which received a new impetus during the 1930's because of lack of employment opportunities in urban areas and because of migration to the Pacific Northwest of distressed agricultural populations from other areas. Over one-half of the 1,051 families living in the 5 local areas studied had moved on their farms since 1929. About 50 percent of the recent settlers were from the State of Washington, and slightly less than one-half of those from outside Washington, or 22 percent of all new settlers, came from the Great Plains region. Because of the variable quality of soils in western Washington, it is deemed highly important that only the land containing the better soils be cleared. Dairy and poultry production offered the major possibilities for farm income in western Washington.

In a study of the relocation and readjustment in the Wappapello Basin area of approximately 450 families, 304 of whom were farm families who had to be moved, the Missouri station reported that most of the families in need of help had been served by local welfare agencies in their resettlement in other areas. The station concludes that unless early attention is given to the problems of family displacement, the social good to accrue from the project as a whole is likely to be in part nullified by the disadvantages suffered by the people displaced.

In a study of families in the rural areas of northern Wisconsin, the Wisconsin station found that at least one-fifth of the families living in such areas are not real farmers, never wanted to be farmers, and probably never will be successful farmers, no matter how much assistance is given them. There is another problem group, comprising about 25 percent of the open-country population of the cut-over region, who are much better risks for rehabilitation. What they need is help in making a success of farming.

A study by the New York (Cornell) station of types of families residing on marginal and submarginal land in Chemung County showed that there was a high percentage (85 percent) of native Americans, and that 40 percent of the male heads of families were born in the county. Socioeconomic status was found to be directly related to the land class.

In a study of rural families the Minnesota station found that families on W. P. A. in Kanabec County manifested a lower morale and less satisfactory social adjustment than non-W. P. A. families. The rural community has been brought in much closer contact with the social currents of the Nation during the depression through the W. P. A., and local initiative and effort are geared more completely to the larger social programs than they were before 1930.

In a study of 83 white farm-owner families in poor agricultural areas of Mississippi and 111 white sharecropper families in the Yazoo-Mississippi Delta, the Mississippi station found that owner families had on the whole somewhat higher incomes than did cropper families, but that the greatest difference in these two groups was in source of income. The croppers had a larger proportion of their income in the form of cash derived from the sale of crops; the owners had a larger part of theirs in the form of farm-furnished goods and in cash from work off the farm.

AGRICULTURAL LEADERSHIP

In a study of sources of agricultural leadership in Adair County, the Iowa station found that the farmers interviewed looked to fellow township residents for leadership, especially to farmers who had had experience in organizations or programs related, in some degree, to the problem at hand. Farmers would seek advice on social problems from townspeople, frequently salaried specialists, but they would not look to such persons for active community leadership and there was little evidence of such over-all leadership, most leaders being selected only for specific problems.

RURAL ATTITUDES

A study by the Michigan station showed that, although residents in rural communities have a great variety of interests pertaining to their community, those relating to personal affairs and personal relationships are the dominant ones. Community leaders or other persons who are interested in the development of objectives in community life like efficient government, good farming, or adult education may expect a more satisfactory response from the community if the personal aspect of the activities associated with such values is emphasized. An analysis of editorials shows that the rural weekly papers contributed to the development of interests pertaining to local community affairs by directing the attention of readers to matters which might otherwise be overlooked or by interpreting events relating to the community.

In a comparison by the Arkansas station of attitudes toward farm practices and community and public institutions, somewhat less interest was found for tenants than for owners. Only 57.5 percent of the tenants attended community meetings as compared with 81.4 percent of the owners, and 18.5 percent of tenants stated they had no interest in such meetings as compared with 5.2 percent for owners. Only 20.8 percent of tenants belonged to any type of organization, compared with 31.2 percent for owners, and for farm organizations the figures were 8.3 and 16.9 percent. Children were kept out of school for farm work by 37.5 percent of the tenants as compared with 19.5 percent of the owners.

RURAL ORGANIZATIONS

The Iowa station made an analysis of the organizations of two farm-trade centers, finding that Grand Junction, with a population of 1,125 had only 29 organizations in 1940, while Scranton, with a population of 1,014 had 43, or nearly 50 percent more. These differences are distributed proportionately among religious, social, fraternal, and other types of organizations. On the other hand, Scranton had only 40 places of business while Grand Junction had 48.

In a rural-community survey, the Virginia station found well-integrated communities in Virginia. Many forces have tended to break down the old neighborhood units, and while recrystallization around larger centers is in process it proceeds slowly.

In a study of membership in farm organizations, the New York (Cornell) station found that for 2,925 farm operators in 4 counties the average enrollment was 1.8 organizations each, and that 50 percent belonged to only 1 organization or to none. Farm-bureau members belonged to more organizations than members of other organizations, and farmers belonging to cooperatives participated in other organizations and in community activities to a considerably greater extent than farmers not members of cooperatives. The New York (Cornell) station found that rural organizations tend to center their activities largely around those participating rather than nonparticipants.

RURAL WELFARE

The New York (Cornell) station found that the cost of public welfare or relief in the State is one of the three largest governmental expenditures. Total relief expenditures in the State have increased approximately 10 times since 1928. National-defense activity has increased the amount of home relief and W. P. A. expenditures, while expenditures for dependent children, old-age assistance, and assistance to the blind show a continuous upward trend. A study of crime and delinquency in certain parts of the State by the Utah station indicated that farm dwellers rank highest in favorable attitude toward the law and its observance. The Michigan station carried on a study of the administration of public relief in selected rural counties, which indicated that in the improvement of public institutions, factual information was unimportant in comparison with the opinions and attitudes of typical interested groups. The length of time required to effect substantial reorganization, in this case 10 years, is regarded as characteristic of institutional change in general.

RURAL HOUSING

In a study of rural housing in Pennsylvania, the station found the best farm housing in the southeastern and northeastern counties and the best rural nonfarm housing throughout the southeastern and northwestern counties. The greatest difference between rural farm and nonfarm population is in the north-central counties. The rural nonfarm indices appear to be more directly influenced by large cities than are the farm indices.

RURAL HEALTH

The Missouri station reported that the problem of rural medical service is complicated by psychological as well as economic factors. Any steps toward an effective solution of the problem must deal with these factors as well as with the problem of ability to pay.

In a study of rural health, the Minnesota station found that physicians in Minnesota are not distributed equally between rural and urban centers. The number of osteopaths, chiropractors, and midwives has declined at about the same proportion in rural and urban areas. There were 16 counties without general hospitals in 1939, but the number of beds increased more rapidly in rural than in urban centers during the 10-year period since 1930.

STATISTICS OF THE EXPERIMENT STATIONS

In tables 1 to 8 there have been assembled data of a statistical character concerning the personnel, publications, income, and expenditures of the experiment stations for the fiscal year ended June 30, 1941; also disbursements from the United States Treasury to the States, Alaska, Hawaii, and Puerto Rico for agricultural experiment stations under the Federal-grant acts.

PERSONNEL AND PUBLICATIONS

The number of research workers on the station staffs in 1941 was 4,755, an increase of 162 over 1940. The increase consisted of 45 full-time research workers and 117 whose time was divided between research and resident teaching or extension, or research and both resident teaching and extension work. Of the 4,755 technical workers in 1941, 2,303 gave their full time to research while the time of the other 2,452 was devoted partly to research and partly to resident teaching or extension work or both.

The publications of the experiment stations in 1941 included 834 bulletins and circulars in the regular series, 2,411 articles in scientific journals, and 701 miscellaneous publications. The comparable figures for 1940 were 732, 2,386, and 486, respectively.

INCOME

The total income available to the stations for 1941 was $22,433,550.29 as compared with $21,216,748.61 in 1940. The 1941 income consisted of $6,862,500 from the 4 Federal-grant funds and $15,571,050.29 of non-Federal funds, including State appropriations, special endowments and fellowships, fees, sales, miscellaneous, and the unexpended balances from the preceding year.

Federal grants.—Federal grants to the States, Territories, and Puerto Rico for agricultural research in 1941 amounted to $6,862,500 as compared with $6,848,750 in 1940. The increase of $13,750 consisted of $7,500 to Hawaii, $5,000 to Puerto Rico, and $1,250 to Alaska under the Purnell Act.

Non-Federal funds.—The amount of funds made available by the States in 1941 was $15,571,050.29 as compared with $14,367,998.61 in 1940, an increase of $1,203,051.68. The income of the stations from sources other than Federal-grant funds was approximately $2.27 for each $1 of income from the Federal grants.

EXPENDITURES

Classified expenditures for each station under the Hatch Act are shown in table 3, the Adams Act in table 4, the Purnell Act in table 5, the Bankhead-Jones Act in table 6, and for non-Federal funds in table 7.

DISBURSEMENTS OF FEDERAL-GRANT FUNDS

Table 8 shows the total disbursements from the United States Treasury to June 30, 1941, to each State, Alaska, Hawaii, and Puerto Rico for agricultural experiment stations under the Hatch, Adams, Purnell, and Bankhead-Jones and supplementary acts.

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TABLE 1.—*Organization, personnel, and publications of the experiment stations for the year ended June 30, 1941*

Station	Date of legislative assent to Hatch Act	Date of organization under Hatch Act	Personnel					Publications					
			Full-time research	Research and teaching	Research and extension	Research, teaching, and extension	Total research workers	Station publications		Articles in scientific journals		Miscellaneous publications	
			Number	*Number*	*Number*	*Number*	*Number*	*Number*	*Pages*	*Number*	*Pages*	*Number*	*Pages*
Alabama	Feb. 27, 1889	Apr. 1, 1888	39	34	1	1	75	4	175	16	109	25	358
Alaska	May 2, 1929	May 1, 1931	4	1	1		6						
Arizona	Mar. 19, 1889	July 1, 1889	22	37			59	9	419	21	179	14	217
Arkansas	Mar. 7, 1889	Apr. 2, 1888	25	46	3	2	76	9	360	20	120		
California	Mar. 12, 1889	Mar. 13, 1888	104	197			301	24	1,771	387	2,228	216	2,843
Colorado	Mar. 25, 1889	Feb. 20, 1888	26	41	1		68	15	527	17	160	13	116
Connecticut:													
State	May 18, 1887	May 18, 1887	52				52	17	769	25	182	14	57
Storrs	do	Apr. 1, 1888	21	7	1	14	43	1	42				
Delaware	Apr. 14, 1887	Feb. 21, 1888	10	12	3	3	28	6	281	28	155		
Florida	June 7, 1887	Mar. 16, 1888	75	8	4	6	93	27	760	54	210	78	126
Georgia	Dec. 24, 1888	Feb. 18, 1888	46				46	22	546				
Hawaii	Mar. 31, 1911	July 1, 1929	29	17			46	5	243	15	159		
Idaho	Jan. 23, 1891	Feb. 26, 1892	14	34	2	6	56	7	193	7	14		
Illinois	May 11, 1887	Mar. 21, 1888	59	84	2	10	155	11	524				
Indiana	Jan. 19, 1889	July 1, 1887	92	36	3	2	133	21	816	60	288	14	90
Iowa	Mar. 1, 1888	Feb. 17, 1888	97	120	21	13	251	32	1,496	113	850	2	420
Kansas	Mar. 3, 1887	Feb. 8, 1888	32	103			135	19	723	30	100	1	4
Kentucky	Feb. 20, 1888	Apr. 29, 1888	69	25	1	7	102	16	1,107	35	175		
Louisiana	July 12, 1888	Apr. 5, 1887	52	23		1	76	13	344	55	430	24	170
Maine	Mar. 16, 1887	Feb. 16, 1888	39	8			47	8	639	9	76	4	85
Maryland	Mar. 6, 1888	Mar. 9, 1888	19	31	3	14	67	6	340	31	167	23	158
Massachusetts	Apr. 20, 1887	Mar. 2, 1888	71	18			89	20	485	34	256		
Michigan	Apr. 12, 1889	Feb. 26, 1888	53	84	6	5	148	20	1,222	66	423		
Minnesota	Feb. 4, 1889	Jan. 26, 1888	51	118	5	2	176	10	510	79	158	7	14
Mississippi	Jan. 31, 1888	Spring 1888	38	21		1	60	18	623	6	44		
Missouri	June 11, 1889	Jan. 31, 1888	17	87		1	105	28	1,521	80	160	1	52
Montana	Feb. 16, 1893	July 1, 1893	26	18	2	10	56	19	416	15	30	11	459
Nebraska	Mar. 31, 1887	June 14, 1887	25	45	2		72	10	436	27	54		
Nevada	Feb. 8, 1889	December 1887	18	2			20	3	91				

New Hampshire	Aug. 4, 1887	Feb. 22, 1888	7	41	2	3	53	13	342	4	27		
New Jersey:													
College	Mar. 16, 1887	Mar. 5, 1888	68	56	1	4	129	32	610	84	168	2	83
State													
New Mexico	Feb. 28, 1889	Nov. 14, 1889	10	23		2	35	35	530	5	38	2	20
New York:													
Cornell	Mar. 30, 1887	Apr. 30, 1888	43	120	5	19	187	34	1,374	448	2,490		
State	(1)		78				78	18	478	65	130	7	13
North Carolina	Mar. 7, 1887	Dec. 5, 1889	51	24	3	5	83	7	182	14	75	9	26
North Dakota	Mar. 8, 1890	Oct. 15, 1890	25	21		1	47	25	756	10	148		
Ohio	Mar. 16, 1887	Apr. 2, 1888	85	31	1	4	121	15	601				
Oklahoma	Oct. 27, 1890	Aug. 14, 1891	25	60			85	19	652	54	233	14	103
Oregon	Feb. 25, 1889	July 2, 1888	64	55		5	124	56	1,071	35	70		
Pennsylvania	June 3, 1887	June 30, 1887		164			164	15	403	38	352	14	149
Puerto Rico	Aug. 16, 1933	Nov. 14, 1935	53				53	10	366	2	15		
Rhode Island	Mar. 31, 1887	Nov. 3, 1881	15	7		5	27	9	351	10	58	4	68
South Carolina	Dec. 22, 1887	January 1888	63	21	2	1	87	5	441				
South Dakota	Mar. 11, 1887	Nov. 17, 1887	11	30	1	3	45	16	452	13	52		
Tennessee	Mar. 29, 1887	July 24, 1887	63	19			82	14	358	16	113		
Texas	Apr. 2, 1887	Jan. 25, 1888	158	2			160	18	1,205	26	213	60	238
Utah	Mar. 8, 1888	Nov. 16, 1889	27	36	1	6	70	16	370	23	143		
Vermont	November 1888	Feb. 28, 1888	23	17	1		41	13	516	3	28		
Virginia	Feb. 29, 1888	June 13, 1888	47	14	1	5	67	18	611	29	174		
Washington	Mar. 9, 1891	May 1, 1891	66	35			101	24	1,044	42	266	29	301
West Virginia	Feb. 22, 1889	June 11, 1888	25	37	1	6	69	6	294	26	204	3	56
Wisconsin	Session 1889	July 1, 1887	53	78	5	24	160	5	335	225	450	102	40[2]
Wyoming	Jan. 10, 1891	Mar. 27, 1891	18	28			46	11	275	9	30	8	28
Total			2,303	2,761	85	191	4,755	834	30,996	2,411	12,204	701	6,662

[1] First made eligible to receive part of the State allotment of Federal funds by legislative act approved May 12, 1894.

TABLE 2.—*Income of the experiment stations for the year ended June 30, 1941*

Station	Federal grants [1]			Non-Federal							Grand total
	Hatch, Adams, and Purnell [2]	Bankhead-Jones	Total	Balance from previous year	State appropriations	Special endowments, industrial fellowships, etc.	Fees	Sales	Miscellaneous	Total	
Alabama	$90,000	$82,695.12	$172,695.12	$190,114.88	$162,300.00	$19,887.34		$97,884.26		$470,186.48	$642,881.60
Alaska	25,000	2,236.48	27,236.48	50.00	6,875.00			17,284.59		24,209.59	51,446.07
Arizona	90,000	12,422.56	102,422.56	1,925.47	105,054.66			27,060.94		134,041.07	236,463.63
Arkansas	90,000	63,983.20	153,983.20		83,973.37			32,303.46		116,276.83	270,260.03
California	90,000	65,941.96	155,941.96	68,150.04	1,111,371.64	88,613.25		91,244.88		1,359,379.81	1,515,321.77
Colorado	90,000	22,430.96	112,430.96	35,100.48	85,420.14	7,923.90		34,282.31		162,726.83	275,157.79
Connecticut:											
State	45,000	10,329.04	55,329.04		255,517.37	7,306.94	$28,781.71			291,606.02	346,935.06
Storrs	45,000	10,329.04	55,329.04	5,151.64	45,995.00	5,523.75	16,560.84			73,231.24	128,560.28
Delaware	90,000	5,010.20	95,010.20	2,706.75	21,925.00			17,812.75	$5,010.20	47,454.70	142,464.90
Florida	90,000	30,801.64	120,801.64	155,511.20	539,928.88			67,840.75		763,280.83	884,082.47
Georgia	90,000	87,522.92	177,522.92	5,952.69	39,397.00	29,329.81		29,465.39	49,378.11	153,523.00	331,045.92
Hawaii	67,500	9,186.40	76,686.40	40.01	9,186.40	1,200.00		23,304.40	70,648.10	104,378.91	181,065.31
Idaho	90,000	13,718.56	103,718.56	10,041.88	32,812.85	575.00		24,482.42		67,912.15	171,630.71
Illinois	90,000	86,736.52	176,736.52		406,723.80	21,555.69		77,218.14		505,497.63	682,234.15
Indiana	90,000	62,722.60	152,722.60	313,954.14	298,300.00	89,199.10	216,358.02	131,699.88	44,475.07	1,093,986.21	1,246,708.81
Iowa	90,000	64,854.64	154,854.64	24,778.46	257,941.42	52,950.27		28,261.66	22,028.11	385,959.92	540,814.56
Kansas	90,000	50,050.96	140,050.96	35,721.54	124,757.50		48,366.64		2,560.00	211,405.68	351,456.64
Kentucky	90,000	78,938.04	168,938.04	46,475.06	110,448.09		197,394.56	48,267.39		402,585.10	571,523.14
Louisiana	90,000	55,133.44	145,133.44		188,232.29	6,646.99		14,538.46		209,417.74	354,551.18
Maine	90,000	20,692.16	110,692.16	4,403.01	75,916.19	1,500.00	19,917.14	10,523.77	9,169.15	121,429.26	232,121.42
Maryland	90,000	28,550.48	118,550.48	29,597.23	75,634.00	11,249.59	2,629.65	33,618.64		152,729.11	271,279.59
Massachusetts	90,000	18,182.20	108,182.20		202,323.19	10,270.13			693.62	213,286.94	321,469.14
Michigan	90,000	66,967.84	156,967.84		283,794.58			32,780.68		316,575.26	473,543.10
Minnesota	90,000	56,797.64	146,797.64		391,619.56	27,370.85		53,496.14	6,028.07	478,514.62	625,312.26
Mississippi	90,000	72,651.40	162,651.40	35,143.98	122,833.12	2,000.00		73,057.77	10,470.54	243,505.41	406,156.81
Missouri	90,000	76,967.80	166,967.80	28,093.94	120,829.56	21,103.03	34,334.46	35,795.04		240,156.03	407,123.83
Montana	90,000	15,503.16	105,503.16	16,760.94	73,301.42			56,512.07		146,574.43	252,077.59
Nebraska	90,000	38,776.60	128,776.60		132,545.00			87,693.13		220,238.13	349,014.73
Nevada	90,000	2,460.64	92,460.64	825.30				11,103.76		11,929.06	104,389.70
New Hampshire	90,000	8,357.20	98,357.20	29,262.28	8,357.20			3,434.01	23,350.67	64,404.16	162,761.36
New Jersey	90,000	30,525.84	120,525.84		519,848.00					519,848.00	640,373.84
New Mexico	90,000	13,761.00	103,761.00	35,795.65	13,788.00			22,873.82		72,457.47	176,218.47

New York:											
Cornell	81,000	80,848.48	161,848.48		713,760.97		37,106.62	86,582.12	1,738.27	839,187.98	1,001,036.46
State	9,000	8,983.16	17,983.16	5,602.56	362,007.59			18,244.85		385,855.00	403,838.16
North Carolina	90,000	102,628.00	192,628.00	5,999.88	90,092.40	14,513.90		20,764.83		131,371.01	323,999.01
North Dakota	90,000	24,675.76	114,675.76	4,021.02	76,329.40	1,396.60	2,147.76	37,655.97	1,725.00	123,275.75	237,951.51
Ohio	90,000	93,014.76	183,014.76	345,198.13	664,225.00			131,075.99	13,933.98	1,154,433.10	1,337,447.86
Oklahoma	90,000	68,450.84	158,450.84	65,247.84	179,068.61	2,977.54	47,347.60	56,549.49		351,191.08	509,641.92
Oregon	90,000	20,175.80	110,175.80		221,102.67	10,856.85	18,272.74	86,577.79		336,810.05	446,985.85
Pennsylvania	90,000	134,689.52	224,689.52	5,297.37	169,959.29				40,469.21	215,725.87	440,415.39
Puerto Rico	50,000	48,552.16	98,552.16		164,432.93			7,272.48	[3] 25,000.00	196,705.41	295,257.57
Rhode Island	90,000	2,263.84	92,263.84	275.69				5,672.75		5,948.44	98,212.28
South Carolina	90,000	59,464.96	149,464.96	7,336.62	127,480.00			114,292.39		249,109.01	398,573.97
South Dakota	90,000	24,432.44	114,432.44	17,409.58	25,560.00	4,893.91		32,867.90		80,731.39	195,163.83
Tennessee	90,000	74,783.88	164,783.88		59,214.64			52,094.02		111,308.66	276,092.54
Texas	90,000	149,364.76	239,364.76	96,265.02	377,483.00	4,049.25		197,691.89	132,572.96	808,062.12	1,047,426.88
Utah	90,000	10,503.68	100,503.68	9,043.90	40,388.00	3,830.00		14,999.49	1,251.99	69,513.38	170,017.06
Vermont	90,000	10,471.60	100,471.60	722.76			26,469.44	626.72	3,120.45	30,939.37	131,410.97
Virginia	90,000	71,144.56	161,144.56		113,710.00			12,009.88	440.00	126,159.88	287,304.44
Washington	90,000	29,515.72	119,515.72		191,598.30	5,157.79		47,658.83		244,414.92	363,930.64
West Virginia	90,000	53,813.44	143,813.44	9,055.96	44,500.00			35,258.61		88,814.57	232,628.01
Wisconsin	90,000	60,224.88	150,224.88		319,842.00	127,782.00		72,175.00		519,799.00	670,023.88
Wyoming	90,000	6,759.52	96,759.52	30,359.37	60,159.63			25,584.27	6,883.41	122,986.68	219,746.20
Total	4,462,500	2,400,000.00	6,862,500.00	1,677,392.27	9,907,864.66	579,663.49	695,687.18	2,239,495.78	470,946.91	15,571,050.29	22,433,550.29

[1] Includes unexpended balances from the previous year as follows:
Hatch—Connecticut Storrs, $6.38; Illinois, $0.29; North Dakota, $9.34; Rhode Island, $2.72.
Adams—Illinois, $0.51; North Dakota, $31 57.
Purnell—Connecticut Storrs, $0.21; New York Cornell, $25.94; North Dakota, $107.13; Oklahoma, $92.28; Rhode Island, $8.31.
Bankhead-Jones—Connecticut Storrs, $3.90; Illinois, $2.61; New York Cornell, $39.39; North Dakota, $65.89; Oklahoma, $508.38; Rhode Island, $172.49.

[2] Hatch, $15,000 for each State, Alaska, Hawaii, and Puerto Rico.
Adams, $15,000 for each State, Hawaii, and Puerto Rico; and $7,500 for Alaska.
Purnell, $30,000 for each State; $2,500 for Alaska; $37,500 for Hawaii; and $20,000 for Puerto Rico.

[3] Puerto Rico, $25,000 loan for purchase of land.

TABLE 3.—*Expenditures and appropriations under the Hatch Act (Mar. 2, 1887)[1] for the year ended June 30, 1941*

Station	Expenditures												Unexpended	Appropriation
	Personal services	Supplies and materials	Communication service	Travel	Transportation of things	Publications	Heat, light, water, power, and fuel	Contingent	Equipment	Land	Structures and nonstructural improvements	Total		
Alabama	$12,426.75	$580.15	$230.50	$39.20	$129.42	$287.06	$94.60	$50.01	$1,100.52	$61.79		$15,000.00		$15,000
Alaska	10,711.88	2,097.10	58.49	209.02	370.08		675.54		721.31		$156.58	15,000.00		15,000
Arizona	14,820.65		2.21	177.14								15,000.00		15,000
Arkansas	9,037.16	1,980.83	68.29	513.77		1,561.87	80.17		672.54		750.00	14,664.63	$335.37	15,000
California	15,000.00											15,000.00		15,000
Colorado	15,000.00											15,000.00		15,000
Connecticut:														
State	7,500.00											7,500.00		7,500
Storrs	5,170.00	190.25	24.44	150.00	.89	22.13	27.09		1,904.28			7,489.08	10.92	7,500
Delaware	9,955.98	1,234.94	1,203.12	542.50	47.29	568.97	96.18	3.85	1,347.17			15,000.00		15,000
Florida	14,992.25		7.75									15,000.00		15,000
Georgia	9,614.07	1,348.39	271.92	497.03	38.72	1,102 83	742.10	46.80	1,254.06		84.08	15,000.00		15,000
Hawaii	13,050.23	732.22			2.50	767.50	355.05	5.00	87.50			15,000.00		15,000
Idaho	9,706.79	1,871.81	177.05	940.11	12.08	935.31	58.57	62.70	1,135.18		100.40	15,000.00		15,000
Illinois	15,000.00											15,000.00		15,000
Indiana	15,000.00											15,000.00		15,000
Iowa	15,000.00											15,000.00		15,000
Kansas	13,937.24	217.84	30.54	338.14		22.09			410.15		44.00	15,000.00		15,000
Kentucky	14,271.12	50.93	101.95	146.50	1.50	428.00						15,000.00		15,000
Louisiana	12,925.00	575.27	13.11	266.07	7.09	813.57	40.11	47.70	312.08			15,000.00		15,000
Maine	11,205.35	630.86	428.18	524.50	120.33		1,064 30	32.75	993.73			15,000.00		15,000
Maryland	12,292.40	1,377.79	15.36	568.45	3.25		162.79		533.79		46.17	15,000.00		15,000
Massachusetts	14,235.03			764.97								15,000.00		15,000
Michigan	15,000.00											15,000.00		15,000
Minnesota	14,471.48	13.91			3.77	6.40			504.44			15,000.00		15,000
Mississippi	10.661.06	472.94	297.23	1,040.58	233.26	1,039.46	214.94	11.85	857.13		171.55	15,000.00		15,000
Missouri	15,000.00											15,000.00		15,000
Montana	12,424.39	643.42	472.23	325.61	13.15	562.03	134.29		392.19		32.69	15,000.00		15,000
Nebraska	15,000.00											15,000.00		15,000
Nevada	9,682.00	1,702.83	546.50	203.66	44.70	142.40	148.73	24.25	2,461.23		43.70	15,000.00		15,000
New Hampshire	9,420.35	755.28	498.02	795.17	310.20	676.29	700.00	5.00	1,827.22		12.47	15,000.00		15,000
New Jersey	12,542.20	319.21	144.50	915.76		204.72	98.60	18.00	744.01		13.00	15,000.00		15,000

New Mexico	12,896.73	1,052.42	40.17	122.10	93.71	319.45	6.00	51.04	418.38			15,000.00		15,000
New York:														
Cornell	11,251.28	1,505.01							739.21		4.50	13,500.00		13,500
State	1,449.99								50.01			1,500.00		1,500
North Carolina	11,118.14	453.51	194.68	709.02	1.76	1,031.41			1,491.48			15,000.00		15,000
North Dakota	13,435.05	257.65	41.74	176.61	9.99	663.24			261.38		154.34	15,000.00		15,000
Ohio	9,989.61	2,695.96	243.67	163.25		77.93	857.90		696.68		275.00	15,000.00		15,000
Oklahoma	10,624.73	2,019.35	29.50	476.78	34.10	1.50	48.45		1,765.59			15,000.00		15,000
Oregon	12,229.32	583.16	7.15	347.82		1,176.47			641.08		15.00	15,000.00		15,000
Pennsylvania	11,439.10	75.55			.64	2,160.53			1,324.18			15,000.00		15,000
Puerto Rico	8,929.18	822.32	176.35	341.81			30.00		4,700.34			15,000.00		15,000
Rhode Island	10,769.25	1,264.80	91.48	256.66	20.18	577.84	199.48		1,362.87		457.44	15,000.00		15,000
South Carolina	11,435.75	658.30	317.42	369.90	18.95	700.00			1,326.59		172.31	14,999.22	.78	15,000
South Dakota	9,648.03	2,251.18	71.67	343.11	73.56	852.82	67.43		917.38		774.82	15,000.00		15,000
Tennessee	9,667.52	386.19	317.64	100.39	49.71	1,148.56	96.13	13.21	2,536.48		684.17	15,000.00		15,000
Texas	13,663.82	14.75	85.89	520.99					697.96		16.59	15,000.00		15,000
Utah	11,680.23	2,254.71	8.50	438.86	25.30	479.43	35.26		77.71			15,000.00		15,000
Vermont	5,313.74	817.77	449.95	348.02	1.28	4,255.93	2,435.78	3.62	628.82		745.09	15,000.00		15,000
Virginia	12,850.46	661.95	159.14	20.85	49.52	679.92	10.23		500.01		67.92	15,000.00		15,000
Washington	13,524.55	376.92	14.44	530.97		357.87			195.25			15,000.00		15,000
West Virginia	12,426.62	1,308.55	3.95	277.73	10.99	344.29	273.86		332.65		21.36	15,000.00		15,000
Wisconsin	14,583.98	76.17	1.63	338.22								15,000.00		15,000
Wyoming	11,340.10	1,702.07	174.32	147.77	7.82	377.24	603.78		535.36		111.54	15,000.00		15,000
Total	625,320.56	38,034.26	7,020.68	14,989.04	1,735.74	24,345.06	9,357.36	375.78	38,457.94	61.79	4,954.72	764,652.93	347.07	765,000

[1] Extended to Hawaii by act of May 16, 1928; to Alaska by act of Feb. 23, 1929; and to Puerto Rico by act of Mar. 4, 1931.

TABLE 4.—*Expenditures and appropriations under the Adams Act (Mar. 16, 1906)*[1] *for the year ended June 30, 1941*

Station	Expenditures											Unexpended	Appropriation
	Personal services	Supplies and materials	Communication services	Travel	Transportation of things	Heat, light, water, power, and fuel	Contingent	Equipment	Land	Structures and nonstructural improvements	Total		
Alabama	$11,886.56	$1,617.81	$20.00	$164.50	$28.95	$455.00		$557.23	$269.95		$15,000.00		$15,000
Alaska	6,067.71	1,355.29						74.00		$3.00	7,500.00		7,500
Arizona	12,600.16	692.28	21.35	1,231.85	9.90		$1.90	316.15	75.00	51.41	15,000.00		15,000
Arkansas	12,400.67	1,556.70	6.00	283.99		151.00		601.64			15,000.00		15,000
California	15,000.00										15,000.00		15,000
Colorado	14,739.53	196.53	1.83	6.35		47.83		7.93			15,000.00		15,000
Connecticut:													
State	7,500.00										7,500.00		7,500
Storrs	7,500.00										7,500.00		7,500
Delaware	12,297.37	1,214.28	1.45	389.20	16.68		1.40	1,042.12	37.50		15,000.00		15,000
Florida	15,000.00										15,000.00		15,000
Georgia	11,335.37	1,886.11	206.84	43.15	27.81	390.85		931.37		178.50	15,000.00		15,000
Hawaii	14,399.64	454.27			9.92			136.17			15,000.00		15,000
Idaho	13,134.49	826.61		103.80	8.93	10.44	10.70	871.16		33.87	15,000.00		15,000
Illinois	15,000.00										15,000.00		15,000
ndiana	14,392.46	492.08	.81	19.48	.70			94.47			15,000.00		15,000
owa	15,000.00										15,000.00		15,000
Kansas	13,818.70	932.72					6.47	242.11			15,000.00		15,000
Kentucky	14,731.09	262.59			5.49			.83			15,000.00		15,000
Louisiana	12,829.03	1,180.13	4.70	486.69	62.88	18.38	7.38	370.87		39.94	15,000.00		15,000
Maine	13,228.83	759.60		86.63	58.30	6.20		852.88		7.56	15,000.00		15,000
Maryland	13,674.28	684.60	11.40		18.00			611.72			15,000.00		15,000
Massachusetts	15,000.00										15,000.00		15,000
Michigan	15,000.00										15,000.00		15,000
Minnestoa	14,609.65	32.69						357.66			15,000.00		15,000
Mississippi	12,493.58	464.09	3.90	33.73	15.61	620.02	10.40	1,347.27		11.40	15,000.00		15,000
Missouri	10,101.41	3,477.65	7.00	9.90	95.91	65.40		1,108.95		133.78	15,000.00		15,000
Montana	13,653.39	595.58	5.15	630.75	3.67			111.46			15,000.00		15,000
Nebraska	15,000.00										15,000.00		15,000
Nevada	12,974.13	848.73	24.00	171.22				981.92			15,000.00		15,000
New Hampshire	13,838.87	647.68	6.35	67.33	54.84		.75	384.18			15,000.00		15,000
New Jersey	12,063.57	1,778.76		91.76		425.88	21.69	610.95		7.39	15,000.00		15,000
New Mexico	12,312.53	976.80	76.74	257.52	129.18	190.35	105.14	929.24		22.50	15,000.00		15,000

New York:													
Cornell	12,443.10	704.15	4.64					348.11			13,500.00		13,500
State	1,500.00										1,500.00		1,500
North Carolina	12,997.52	582.80	9.79	493.70	19.78		.40	896.01			15,000.00		15,000
North Dakota	13,237.88	504.65	7.37	10.84	17.86			1,029.39		192.01	15,000.00		15,000
Ohio	12,220.53	1,637.56	7.37	18.44	20.27			1,095.83			15,000.00		15,000
Oklahoma	10,134.15	2,314.99			5.17			2,430.83		114.86	15,000.00		15,000
Oregon	12,726.51	901.65	13.59	649.67	.62	13.08	2.67	392.21		300.00	15,000.00		15,000
Pennsylvania	15,000.00										15,000.00		15,000
Puerto Rico	11,667.57	929.90	1.84	534.47	11.23	47.41		1,807.58			15,000.00		15,000
Rhode Island	14,947.61	9.38								43.01	15,000.00		15,000
South Carolina	12,291.87	840.77	123.48	346.74	17.44	392.20		889.80	21.00	76.70	15,000.00		15,000
South Dakota	10,819.20	1,088.45	27.20	575.00	43.66	80.46		1,732.36		633.67	15,000.00		15,000
Tennessee	14,160.90	306.85	.25	139.43	12.44	50.00		165.76	20.00	144.37	15,000.00		15,000
Texas	14,962.44	35.55	2.01								15,000.00		15,000
Utah	12,672.30	899.21	2.05	788.57	65.78			451.70		120.39	15,000.00		15,000
Vermont	13,870.39	548.89	.36	40.64	1.59	9.10		429.03			14,900.00	$100.00	15,000
Virginia	12,175.86	1,106.07	12.15	172.15		13.50		1,259.47		260.80	15,000.00		15,000
Washington	13,021.92	1,304.98	3.93	324.42				344.75			15,000.00		15,000
West Virginia	14,100.00	618.83		41.37				239.80			15,000.00		15,000
Wisconsin	14,623.38	375.95			.67						15,000.00		15,000
Wyoming	13,201.52	1,154.32	15.08	253.70	18.45		5.14	259.61		92.18	15,000.00		15,000
Total	676,357.67	38,798.53	628.63	8,466.99	781.73	2,987.10	174.04	26,314.52	423.45	2,467.34	757,400.00	100.00	757,500.00

[1]Extended to Hawaii by act of May 16, 1928; to Puerto Rico by act of Mar. 4, 1931; and to Alaska by act of June 30, 1936.

TABLE 5—*Expenditures and appropriations under the Purnell Act (Feb. 24, 1925)* [1] *for the year ended June 30, 1941*

Station	Expenditures												Unexpended	Appropriation
	Personal services	Supplies and materials	Communication service	Travel	Transportation of things	Publications	Heat, light, water, power, and fuel	Contingent	Equipment	Land	Structures and nonstructural improvements	Total		
Alabama	$47,449.69	$5,022.87	$104.24	$984.50	$144.38	$655.37	$1,246.85	$35.95	$4,162.52		$193.63	$60,000.00		$60,000
Alaska	1,349.87	1,142.13							8.00			2,500.00		2,500
Arizona	47,180.60	5,432.74	59.37	2,674.83	145.07	553.74	399.29	4.07	2,653.12	$90.00	807.17	60,000.00		60,000
Arkansas	50,291.90	4,256.80	99.64	755.17		788.02	449.75		3,277.98		80.74	60,000.00		60,000
California	60,000.00											60,000.00		60,000
Colorado	53,129.91	1,993.95	92.97	1,620.67	38.08	44.93	99.39	10.30	2,564.22	70.00	335.58	60,000.00		60,000
Connecticut:														
State	25,376.62	2,359.86	4.20	252.00	13.14	112.76	574.42		1,279.41		27.59	30,000.00		30,000
Storrs	26,305.47	1,235.87	200.85	481.48	5.06	30.48	.17	2.00	1,498.93			29,760.31	$239.69	30,000
Delaware	45,297.95	4,408.90	12.10	2,317.67	17.48	3,049.37	673.90	41.00	3,296.25	258.33	627.86	60,000.00		60,000
Florida	51,015.43	3,827.78	19.40	3,044.47	20.73		29.07		2,000.93		42.19	60,000.00		60,000
Georgia	38,991.78	8,458.79	156.31	1,417.47	221.64	584.30	2,122.29	.80	7,701.03		345.59	60,000.00		60,000
Hawaii	35,130.42	1,548.01		2.90	5.70				812.97			37,500.00		37,500
Idaho	51,420.80	3,537.70	138.42	2,061.19	83.67	312.66	12.36	1.50	1,909.82	205.00	316.88	60,000.00		60,000
Illinois	47,353.19	2,465.03	381.07	2,454.40	35.68	2,038.36			5,194.76		2.08	59,924.57	75.43	60,000
Indiana	51,773.06	2,573.74	255.04	3,565.83	32.94		.82	20.14	1,754.43		24.00	60,000.00		60,000
Iowa	60,000.00											60,000.00		60,000
Kansas	54,835.90	2,213.53		379.87	12.00	23.39		150.21	2,086.18		298.92	60,000.00		60,000
Kentucky	48,359.33	1,057.34	184.81	4,639.04	1.92	3,374.20		42.00	2,341.36			60,000.00		60,000
Louisiana	49,908.23	3,182.55	18.67	2,032.12	133.94	272.23	113.57	84.93	3,658.36		595.40	60,000.00		60,000
Maine	49,604.22	4,796.45	2.66	1,143.23	146.85	146.49	750.82		3,325.99	65.00	18.29	60,000.00		60,000
Maryland	48,044.01	4,568.14	115.66	2,848.82	50.40	1,170.97	349.32		2,676.73	45.00	130.95	60,000.00		60,000
Massachusetts	54,254.84	2,037.36	15.50	1,351.31		317.52		14.89	2,006.23			59,997.65	2.35	60,000
Michigan	52,527.42	3,177.12	90.97	1,938.31	11.53	92.10	2.69	110.77	2,049.09			60,000.00		60,000
Minnesota	53,700.56	3,260.32	30.00	1,325.24	181.77	19.50			1,414.36	40.00	28.25	60,000.00		60,000
Mississippi	44,395.63	6,176.73	139.23	1,596.68	88.77	1,844.30	2,297.87	9.26	3,148.52		303.01	60,000.00		60,000
Missouri	38,876.44	9,885.60	113.87	1,588.81	121.42	2,061.45	113.37		5,603.17		1,635.87	60,000.00		60,000
Montana	53,213.80	1,517.74	28.44	1,472.57	20.52	1,042.70	104.90	16.09	1,680.35	741.20	161.69	60,000.00		60,000
Nebraska	50,313.04	3,206.54	30.57	1,026.38	18.52	1,010.38	91.00		2,479.82		1,818.75	59,995.00	5.00	60,000
Nevada	49,031.47	3,379.27	463.70	2,380.02	7.23	372.71	428.37	1.25	2,793.28		1,142.70	60,000.00		60,000
New Hampshire	50,914.46	2,466.19	30.57	2,035.39	92.09	289.44	9.10	13.78	1,871.40	260.00	2,017.58	60,000.00		60,000
New Jersey	52,127.83	3,228.97	45.82	929.65		71.31	480.21	33.25	2,916.60		166.36	60,000.00		60,000

New Mexico	43,386.26	4,507.22	213.80	3,689.30	202.73	988.09	352.42	277.31	5,607.42	212.50	562.95	60,000.00	60,000
New York:													
Cornell	44,720.12	1,750.15	74.96	929.51		10.58		54.05	6,455.45			53,994.82	5.18	54,000
State	5,850.00	62.99		6.00					81.01			6,000.00		6,000
North Carolina	44,934.61	2,975.46	203.88	3,677.11	20.31	294.53	159.49	.20	7,461.22		273.19	60,000.00		60,000
North Dakota	47,631.37	5,759.38	87.12	1,275.71	270.53	2,389.12	119.03		1,915.18		403.04	59,850.48	149.52	60,000
Ohio	44,298.02	6,903.77	7.06	398.58	429.65		1,072.58		6,890.34			60,000.00		60,000
Oklahoma	45,274.11	6,945.58	16.12	682.37	11.50	543.69		25.18	4,062.38		2,439.07	60,000.00		60,000
Oregon	50,927.15	3,197.65	261.32	2,318.77	17.14	1,215.48	102.58	53.96	794.89	37.83	1,073.23	60,000.00		60,000
Pennsylvania	49,725.75	3,216.19	59.84	2,446.78	94.49		569.14	3.64	3,039.61	810.00	34.56	60,000.00		60,000
Puerto Rico	16,833.43	114.16		1,783.94		720.97			547.50			20,000.00		20,000
Rhode Island	47,555.22	5,837.62	19.75	169.52	9.27	335.70	965.54		4,502.96		602.65	59,998.23	1.77	60,000
South Carolina	48,970.13	3,994.13	457.44	1,924.80	50.73	1,006.44	215.17	49.58	2,878.76	452.82		60,000.00		60,000
South Dakota	46,503.65	4,308.37	616.68	2,010.69	132.87	1,748.59	38.18		3,755.37		885.60	60,000.00		60,000
Tennessee	53,978.21	1,833.06	21.14	483.43	45.45	62.78	156.98		2,652.01	32.50	734.44	60,000.00		60,000
Texas	53,267.60	2,686.96	364.55	1,353.30	118.00		12.80	16.00	2,024.44		156.35	60,000.00		60,000
Utah	49,022.87	3,319.33	66.97	2,973.42	40.47	25.00	61.67	22.00	3,503.19	777.50	187.58	60,000.00		60,000
Vermont	47,945.45	2,879.76	38.07	1,273.49	31.56		102.40		6,462.15	52.50	1,214.62	60,000.00		60,000
Virginia	48,542.09	2,129.02	3.35	2,770.47	4.70	2,262.61			4,004.94		282.82	60,000.00		60,000
Washington	51,151.13	2,832.01	39.27	1,909.72	1.63	1,647.33		6.21	2,396.05		16.65	60,000.00		60,000
West Virginia	50,320.05	3,546.28	2.00	1,012.68	213.72	644.06	439.74	5.05	3,708.54		107.88	60,000.00		60,000
Wisconsin	58,921.06	459.01	2.09	562.29			3.14		52.41			60,000.00		60,000
Wyoming	48,072.89	7,688.23	29.90	2,110.10	64.80	584.31	109.35	15.92	1,253.63	44.54	26.33	60,000.00		60,000
Total	2,440,005.04	179,363.54	5,419.39	84,082.00	3,410.08	34,757.96	14,829.74	1,121.29	152,215.26	4,194.72	20,122.04	2,939,521.06	478.94	2,940,000.00

[1] Extended to Hawaii by act of May 16, 1928; to Puerto Rico by act of Mar. 4, 1931; and to Alaska by act of June 20, 1936.

TABLE 6.—*Expenditures and appropriations under the Bankhead-Jones Act (June 29, 1935) for the year ended June 30, 1941*

Station	Expenditures												Unexpended	Appropriation
	Personal services	Supplies and materials	Communication service	Travel	Transportation of things	Publications	Heat, light, water, power, and fuel	Contingent	Equipment	Land	Structures and nonstructural improvements	Total		
Alabama	$61,755.87	$8,505.13	$150.12	$2,489.12	$434.86	$354.55	$1,683.21	$53.63	$3,439.19	$5.00	$3,824.44	$82,695.12		$82,695.12
Alaska	1,180.84	867.64									188.00	2,236.48		2,236.48
Arizona	10,344.82	351.29	41.84	1,317.60	3.77		11.40		293.51	58.33		12,422.56		12,422.56
Arkansas	49,969.27	5,585.38	92.64	2,617.51		911.69	322.38		3,677.87		806.46	63,983.20		63,983.20
California	65,941.96											65,941.96		65,941.96
Colorado	20,108.79	418.65	29.27	1,402.96			17.42	20.75	433.12			22,430.96		22,430.96
Connecticut:														
State	8,360.00	764.38		87.98	.56		795.25	4.18	288.40		28.29	10,329.04		10,329.04
Storrs	9,366.01	644.59	.70	11.80	5.10	14.10	14.54		266.08			10,322.92	$6.12	10,329.04
Delaware	3,301.92	1,043.49			58.80		65.60		43.45		496.94	5,010.20		5,010.20
Florida	20,840.41	2,427.25	1.43	1,117.75	252.01		240.73		5,181.71		740.35	30,801.64		30,801.64
Georgia	50,492.29	9,900.02	531.33	2,726.33	906.22	1,074.63	2,431.60	4.86	13,910.01	3,647.11	1,898.52	87,522.92		87,522.92
Hawaii	7,542.98	1,407.59			14.21			5.28	180.26		36.08	9,186.40		9,186.40
Idaho	10,684.74	1,417.52	2.05	787.05	12.20			9.10	399.69	240.00	166.21	13,718.56		13,718.56
Illinois	69,096.00	4,229.01	138.63	3,686.54	87.95	78.30	1,216.62	.99	7,922.58		279.90	86,736.52		86,736.52
Indiana	46,968.15	5,994.69	64.70	2,091.19	76.32		38.20	10.20	6,521.33	6.00	951.82	62,722.60		62,722.60
Iowa	60,112.29		6.32		88.52		11.09				4,636.42	64,854.64		64,854.64
Kansas	40,599.19	4,858.05	1.54	1,589.20	34.35	43.26		.75	1,803.94		1,120.68	50,050.96		50,050.96
Kentucky	68,802.39	4,305.90	191.01	956.09	49.73	1,115.85	39.50		3,005.42		472.15	78,938.04		78,938.04
Louisiana	41,648.69	3,968.66	12.68	1,771.07	67.80	185.22	166.20	66.54	5,677.66		1,568.92	55,133.44		55,133.44
Maine	18,422.03	695.37	1.20	1,324.53	3.43	23.67	3.30		218.63			20,692.16		20,692.16
Maryland	22,605.49	2,725.64	93.27	967.04	9.93	23.90	222.53		1,452.68	442.50	7.50	28,550.48		28,550.48
Massachusetts	17,977.96			12.02		192.22						18,182.20		18,182.20
Michigan	59,390.56	3,434.09	3.48	1,199.71	14.71	42.64	57.25	68.06	2,757.34			66,967.84		66,967.84
Minnesota	44,558.93	4,954.87	45.15	2,877.02	228.85	18.50		13.00	3,428.30	346.69	326.33	56,797.64		56,797.64
Mississippi	45,328.46	6,739.32	521.64	1,419.95	445.78	1,252.94	3,021.73	59.75	12,333.90	299.78	1,228.15	72,651.40		72,651.40
Missouri	53,634.54	11,696.23	559.84	326.95	222.41	1,110.33	981.33	28.27	5,396.81		3,011.09	76,967.80		76,967.80
Montana	14,318.73	675.61		69.82	1.19		25.04	3.09	374.04		35.64	15,503.16		15,503.16
Nebraska	32,666.23	1,673.74	1.82	635.87		848.21		1.29	1,700.07		1,249.37	38,776.60		38,776.60
Nevada	2,241.32	18.81		195.10					5.41			2,460.64		2,460.64
New Hampshire	6,757.73	368.47	8.98	439.00	25.15	232.04	31.58		494.25			8,357.20		8,357.20
New Jersey	24,292.87	3,383.68	.62	1,108.02	1.74	53.33	15.66	1.20	1,498.22	100.00	70.50	30,525.84		30,525.84

New Mexico	8,897.30	1,240.12	71.65	501.19	15.49	669.10		16.68	2,070.82	148.73	129.92	13,761.00		13,761.00
New York:														
Cornell	64,788.99	5,957.36	7.00	1,740.66	37.38	85.59	50.09		8,057.36		115.55	80,839.98	8.50	80,848.48
State	7,388.34	1,043.69		91.49					459.64			8,983.16		8,983.16
North Carolina	77,565.20	6,489.15	276.72	6,081.65	193.05		588.47	4.85	10,319.59	895.32	214.00	102,628.00		102,628.00
North Dakota	20,967.38	1,101.57	56.96	403.91	109.01	648.77	128.63	3.97	1,137.11		99.92	24,657.23	18.53	24,675.76
Ohio	79,848.86	4,174.66	4.88	1,360.86	7.60		582.20		4,063.26	380.00	2,592.44	93,014.76		93,014.76
Oklahoma	47,541.30	12,439.45	30.52	527.07	57.94	352.86	921.78	25.00	4,877.94	22.55	1,654.43	68,450.84		68,450.84
Oregon	16,733.32	566.79	39.42	918.82	7.57	533.29			1,365.99		10.60	20,175.80		20,175.80
Pennsylvania	115,599.10	7,643.72		3,443.02	112.89	531.62	229.42		6,698.01		431.74	134,689.52		134,689.52
Puerto Rico	35,236.21	3,603.59		2,361.55		644.19	147.03		6,096.72		462.87	48,552.16		48,552.16
Rhode Island	1,938.15			9.65		131.50			184.54			2,263.84		2,263.84
South Carolina	45,930.32	4,635.77	292.15	529.00	12.07	79.93	944.92		2,881.23	45.11	4,114.46	59,464.96		59,464.96
South Dakota	17,816.58	3,548.49	17.22	1,014.89	17.25	511.08	74.31		1,055.63		376.99	24,432.44		24,432.44
Tennessee	57,400.87	4,721.97	207.21	1,617.43	473.17	49.98	333.43	7.54	4,016.48	125.00	5,830.80	74,783.88		74,783.88
Texas	122,177.22	10,548.71	198.61	4,612.42	73.78	4.86	140.25	22.02	10,504.87		1,082.02	149,364.76		149,364.76
Utah	9,281.47	382.74		742.80	.85				95.82			10,503.68		10,503.68
Vermont	8,847.29	100.40	.10	153.14	1.41		6.28		1,333.98	20.00	9.00	10,471.60		10,471.60
Virginia	54,749.99	5,944.57	14.49	2,130.21	51.88	36.17	464.78		3,954.98	147.50	3,649.99	71,144.56		71,144.56
Washington	22,693.97	2,876.72	22.74	1,611.21	10.79	10.53	14.09	5.45	2,215.65		54.57	29,515.72		29,515.72
West Virginia	44,925.00	3,801.23	69.30	2,887.34	231.80	387.51	147.98		1,238.88		124.40	53,813.44		53,813.44
Wisconsin	59,453.59	382.10		338.51						50.00		60,224.20	.68	60,224.88
Wyoming	5,232.75	161.89	3.81	790.92	45.46		40.50		484.19			6,759.52		6,759.52
Total	1,914,324.66	174,419.76	3,813.04	67,094.96	4,504.98	12,252.36	16,226.32	436.45	155,816.56	6,979.62	44,097.46	2,399,966.17	33.83	2,400,000.00

TABLE 7.—*Expenditures from non-Federal funds for the year ended June 30, 1941* [1]

Station	Personal services	Supplies and materials	Communication service	Travel	Transportation of things	Publications	Heat, light, water, power, and fuel	Contingent	Equipment	Land	Structures and nonstructural improvements	Total
Alabama	$130,206.22	$40,536.34	$1,843.32	$9,350.09	$2,455.50	$928.56	$8,265.94	$19,416.68	$17,758.28	$270.00	$9,497.69	$240,528.62
Alaska	15,594.18	2,137.07	137.60	103.07	1,122.90	----------	1,846.63	157.16	1,528.16	----------	1,468.15	24,094.92
Arizona	88,897.68	14,110.56	2,000.01	3,141.63	366.74	2,667.33	2,200.83	867.63	15,236.66	----------	325.16	129,814.23
Arkansas	74,046.69	12,343.43	1,651.17	2,654.66	506.19	4.20	2,561.87	2,966.62	13,608.72	11.12	5,922.16	116,276.83
California	847,806.79	93,999.04	13,999.73	45,753.26	2,621.71	77,592.08	29,965.58	7,241.88	50,750.77	292.34	49,990.48	1,220,013.66
Colorado	62,758.22	11,031.36	1,404.28	4,008.46	992.25	3,684.45	5,987.08	750.24	12,823.62	305.59	1,946.77	105,692.32
Connecticut:												
State	230,922.22	8,199.36	2,570.31	7,847.08	101.18	111.36	6,605.97	941.78	9,681.48	----------	24,625.28	291,606.02
Storrs	49,802.27	11,079.17	706.74	889.64	465.07	223.75	988.24	357.11	50.16	----------	----------	64,562.15
Delaware	21,324.82	11,113.11	653.66	368.40	317.51	----------	2,988.81	----------	3,818.38	137.50	3,237.12	43,959.31
Florida	328,332.90	58,838.85	6,496.51	24,809.97	1,932.30	6,714.83	18,341.98	2,314.28	40,989.36	135.00	29,593.28	518,499.26
Georgia	66,876.62	7,775.06	819.53	5,821.60	860.19	467.38	3,761.50	2,779.78	24,369.51	20,989.51	17,070.60	151,591.28
Hawaii	67,764.62	17,414.35	1,024.04	1,311.78	187.88	2,550.24	3,102.68	5,699.47	4,364.22	----------	723.01	104,142.29
Idaho	30,010.66	14,090.64	409.00	2,250.00	350.00	300.00	1,750.00	1,600.00	7,485.97	2,300.00	2,623.57	63,160.84
Illinois	358,701.20	90,092.84	6,000.00	17,000.00	----------	12,000.00	----------	----------	21,703.59	----------	----------	505,497.63
Indiana	425,016.75	123,765.70	8,466.24	24,975.97	2,838.01	8,481.79	18,895.15	8,352.28	51,916.40	475.00	38,963.03	712,146.32
Iowa	223,330.47	61,354.60	2,443.40	11,039.29	1,151.61	19,667.19	1,877.05	15,562.13	20,249.07	----------	1,387.61	358,062.42
Kansas	101,097.03	23,188.95	2,256.48	5,002.98	2,285.40	919.96	5,960.84	773.10	24,017.67	2,523.44	9,884.58	177,910.43
Kentucky	209,224.80	43,949.05	3,159.00	9,395.99	1,228.60	979.78	11,277.25	6,370.64	17,182.63	----------	14,632.82	317,400.56
Louisiana	97,166.24	16,613.09	1,715.18	6,832.04	694.12	55.42	2,926.24	1,427.96	23,650.63	456.89	57,879.93	209,417.74
Maine	68,940.51	10,072.85	774.66	8,548.49	777.14	5,824.20	4,057.23	779.56	12,939.44	230.00	3,902.00	116,846.08
Maryland	68,365.65	26,046.57	1,178.53	3,822.37	174.23	1,396.39	1,938.90	10,262.51	7,832.93	734.75	1,260.81	123,013.64
Massachusetts	176,844.72	13,697.01	2,196.54	5,828.34	1,222.69	3,871.29	1,247.94	348.67	7,482.87	----------	546.87	213,286.94
Michigan	225,767.54	30,524.72	986.77	11,339.86	1,311.60	17,033.49	2,457.85	3,903.80	20,394.13	509.00	2,346.50	316,575.26
Minnesota	334,750.19	53,822.38	2,458.23	7,265.93	1,610.98	4,985.46	23,410.49	7,843.22	24,897.63	164.22	17,305.89	478,514.62
Mississippi	113,506.53	16,317.85	1,302.23	5,447.66	1,718.13	3,295.89	5,119.36	2,558.51	23,684.60	75.00	19,001.95	192,027.71
Missouri	102,155.77	36,649.07	1,662.70	8,945.33	1,234.30	7,867.00	1,460.98	1,708.50	25,549.35	5,249.78	8,592.34	201,075.12
Montana	77,470.12	19,457.58	1,662.15	3,620.97	609.06	1,999.06	7,203.92	705.14	11,375.57	5,191.88	3,283.43	132,578.88
Nebraska	103,331.66	54,591.58	2,223.83	3,490.47	1,390.08	3,361.02	7,843.01	1,670.96	33,594.08	1,669.76	7,071.68	220,238.13
Nevada	2,055.89	316.01	185.94	1,077.19	170.07	66.62	249.62	276.96	514.99	99.06	503.17	5,515.52
New Hampshire	25,525.12	4,714.49	358.92	950.34	122.80	1,080.94	127.81	91.30	1,798.17	60.00	----------	34,829.89
New Jersey	385,546.46	53,248.21	8,394.37	15,180.54	835.75	5,977.73	18,732.14	12,000.00	9,934.43	57.00	4,975.50	514,882.13
New Mexico	21,194.19	4,601.99	733.27	1,052.69	261.78	673.70	302.26	1,512.12	2,418.11	----------	682.21	33,432.32

New York:												
Cornell	613,746.65	71,164.67	6,078.01	26,430.29	1,365.08	12,076.05	52,238.01	5,536.28	29,467.01	1,454.55	19,631.38	839,187.98
State	298,507.14	30,120.55	1,506.83	8,433.93	1,793.17	10,476.47	12,683.67	5,910.24	1,893.18	4,447.71	10,082.11	385,855.00
North Carolina	63,457.98	15,601.96	1,277.52	10,409.55	10.56	----------	1,504.46	255.02	13,151.64	999.07	11,696.48	118,364.24
North Dakota	42,552.50	22,183.17	907.93	1,469.78	575.45	1,603.05	22,521.34	5,238.31	15,334.27	----------	6,717.22	119,103.02
Ohio	385,361.81	76,105.80	2,944.13	7,889.34	2,017.51	25,769.74	14,103.87	2,605.30	20,007.37	11,014.12	8,703.11	556,522.10
Oklahoma	208,390.88	23,999.92	1,456.70	6,366.70	505.92	3,032.15	2,023.84	4,277.99	29,865.59	4,500.89	3,431.21	287,851.79
Oregon	235,122.19	34,870.36	2,792.38	14,195.85	1,370.42	4,654.41	8,181.64	4,688.12	21,491.85	3,628.66	5,814.17	336,810.05
Pennsylvania	141,097.60	42,312.49	1,465.95	9,873.32	----------	1,864.95	----------	----------	14,157.60	860.78	----------	211,632.69
Puerto Rico	113,634.41	6,807.43	1,274.38	2,452.19	106.33	3,948.66	4,740.19	4,495.58	9,941.63	23,914.00	15,533.95	186,548.75
Rhode Island	943.94	1,192.68	316.60	93.50	63.49	297.50	829.19	27.00	796.50	----------	271.78	4,832.18
South Carolina	95,493.74	53,288.09	1,869.45	3,758.10	695.83	383.76	11,528.11	5,389.20	30,741.09	3,063.05	26,638.03	232,848.45
South Dakota	28,335.11	11,424.24	200.27	1,874.86	211.33	912.18	513.34	72.49	11,329.87	----------	1,769.95	56,643.64
Tennessee	52,720.97	19,104.08	1,009.58	2,427.66	1,826.26	2,493.18	1,797.02	3,303.82	15,112.76	6,911.25	4,602.08	111,308.66
Texas	403,164.76	84,541.72	3,255.47	25,831.73	1,141.69	10,360.76	12,072.65	59,880.51	54,930.47	1,326.64	36,864.64	693,371.04
Utah	37,239.72	5,665.28	862.71	4,182.24	335.13	2,659.96	892.24	565.79	4,804.51	5,287.58	2,653.91	65,149.10
Vermont	22,060.83	1,247.17	171.87	2,227.49	102.10	1,516.88	722.39	598.21	1,125.30	----------	445.96	30,218.20
Virginia	76,674.33	8,337.46	1,323.67	6,876.63	704.24	2,828.66	3,148.60	1,172.25	14,052.41	5,191.91	5,204.17	125,514.33
Wasnington	162,658.78	30,642.69	1,997.48	10,267.12	792.75	1,643.39	9,792.94	4,813.31	15,539.05	287.50	5,979.91	244,414.92
West Virginia	48,358.64	17,573.80	999.05	1,776.38	116.59	268.20	4,231.54	772.79	4,617.77	1,360.00	2,251.42	82,306.18
Wisconsin	378,288.00	63,492.00	1,352.00	11,210.00	----------	3,505.00	2,414.00	448.00	25,161.00	4,129.00	29,800.00	519,799.00
Wyoming	36,074.52	12,857.24	1,929.44	1,919.03	----------	292.40	2,315.61	1,297.10	4,077.76	114.84	----------	60,877.94
Total	8,578,219.23	1,617,925.68	116,856.76	419,071.78	45,649.62	285,368.49	371,709.80	232,587.30	881,200.21	120,428.39	537,335.07	13,206,352.33

[1] For non-Federal income, see table 2.

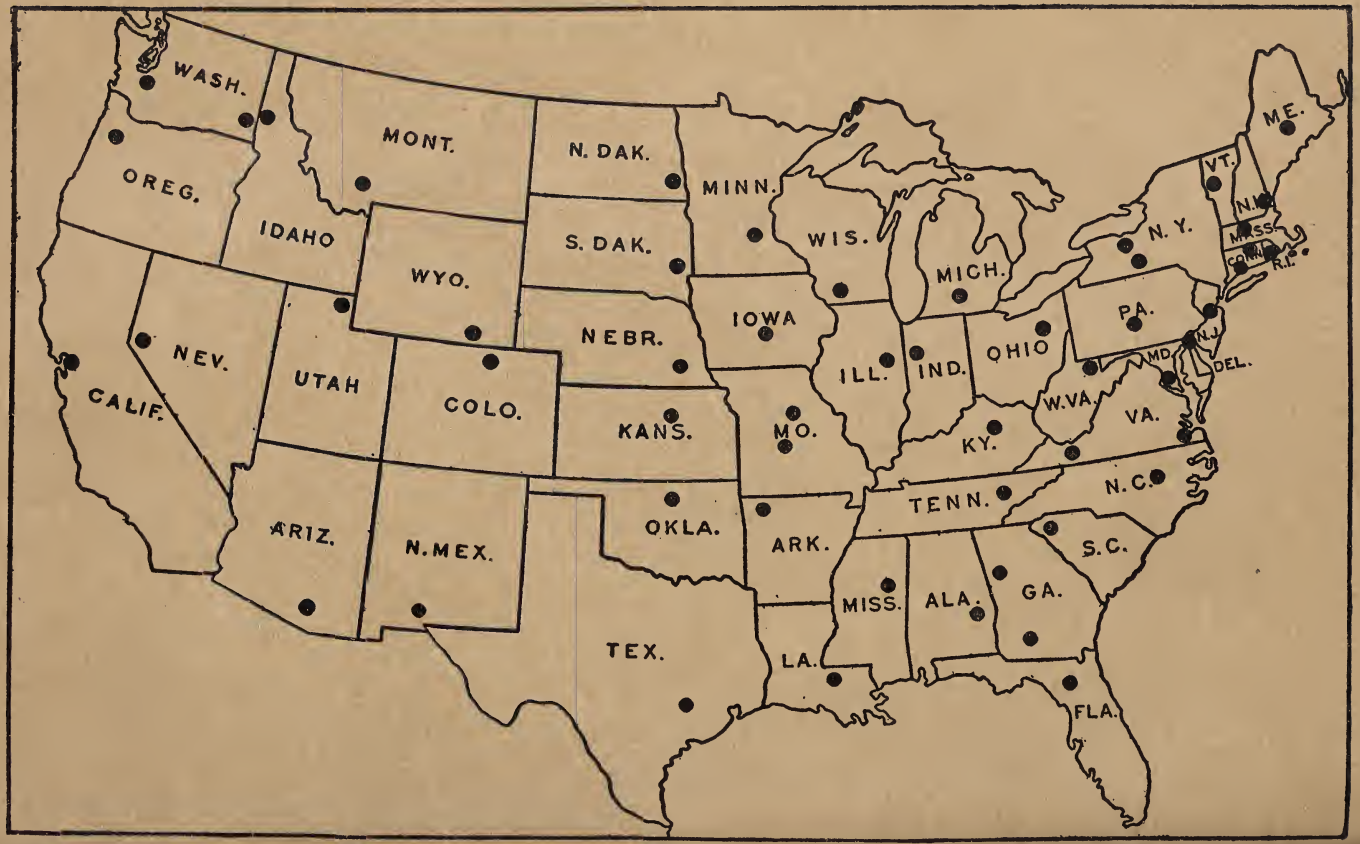
TABLE 8.—*Disbursements from the U. S. Treasury to the States and Territories and Puerto Rico for agricultural experiment stations under the Hatch Act (Mar. 2, 1887), Adams Act (Mar. 16, 1906), Purnell Act (Feb. 24, 1925), Bankhead-Jones Act (June 29, 1935), and supplementary acts*

State or Territory	Hatch Act 1888–1941	Adams Act 1906–41	Purnell Act 1926–41	Bankhead-Jones Act 1936–41
Alabama	$809, 199. 34	$506, 619. 89	$860, 000. 00	$361, 791. 15
Alaska	150, 000. 00	30, 000. 00	5, 000. 00	9, 631. 74
Arizona	774, 803. 10	509, 995. 61	859, 986. 80	54, 348. 70
Arkansas	808, 127. 12	509, 900. 00	860, 000. 00	279, 926. 50
California	810, 000. 00	509, 926. 84	860, 000. 00	288, 496. 07
Colorado	809, 718. 82	508, 638. 93	860, 000. 00	98, 135. 45
Connecticut	809, 968. 60	510, 000. 00	859, 888. 54	90, 339. 46
Dakota Territory	56, 250. 00			
Delaware	808, 382. 87	506, 075. 11	856, 924. 01	21, 919. 63
Florida	809, 966. 06	509, 996. 06	856, 523. 74	134, 757. 17
Georgia	805, 593. 43	497, 092. 87	860, 000. 00	382, 912. 78
Hawaii	179, 919. 17	134, 951. 14	132, 500. 00	40, 190. 50
Idaho	734, 824. 13	505, 842. 22	860, 000. 00	60, 018. 70
Illinois	808, 114. 90	509, 718. 69	850, 339. 72	379, 079. 49
Indiana	809, 901. 19	505. 000. 00	860, 000. 00	272, 173. 91
Iowa	810, 000. 00	510, 000. 00	857, 965. 17	283, 739. 05
Kansas	809, 995. 00	510, 000. 00	860, 000. 00	218, 972. 95
Kentucky	809, 996. 57	510, 000. 00	860, 000. 00	345, 353. 92
Louisiana	810, 000. 00	510, 000. 00	860, 000. 00	241, 208. 80
Maine	809, 999. 62	510, 00. 000	860, 000. 00	90, 528. 20
Maryland	809, 967. 40	509, 236. 48	860, 000. 00	124, 908. 35
Massachusetts	809, 617. 70	510, 000. 00	860, 000. 00	79, 547. 13
Michigan	809, 676. 10	506, 341. 60	860, 000. 00	292, 984. 30
Minnesota	809, 917. 78	509, 345. 74	860, 000. 00	248, 489. 67
Mississippi	810, 000. 00	510, 000. 00	860, 000. 00	317, 849. 88
Missouri	805, 097. 24	509, 999. 90	860, 000. 00	336, 734. 12
Montana	720, 000. 00	507, 417. 04	860, 000. 00	67, 826. 33
Nebraska	809, 932. 16	510, 000. 00	860, 000. 00	169, 647. 62
Nevada	808, 331. 08	506, 145. 10	860, 000. 00	10, 765. 30
New Hampshire	809, 250. 00	510, 000. 00	860, 000. 00	36, 562. 75
New Jersey	809, 959. 97	509, 392. 06	860, 000. 00	133, 550. 55
New Mexico	774, 509. 05	510, 000. 00	860. 000. 00	60, 204. 38
New York	809, 757. 54	509, 189. 22	859, 836. 33	392, 973. 91
North Carolina	810, 000. 00	510, 000. 00	860, 000. 00	448, 997. 50
North Dakota	766, 491. 45	509, 605. 60	859, 886. 73	107, 884. 38
Ohio	810, 000. 00	508, 514. 02	860, 000. 00	406, 939. 58
Oklahoma	741, 919. 88	497, 842. 65	859, 907. 72	298, 964. 04
Oregon	795, 156. 64	505, 000. 00	860, 000. 00	88, 269. 13
Pennsylvania	809, 967. 43	509, 995. 41	860, 000. 00	589, 266. 65
Puerto Rico	104, 762. 63	93, 734. 53	61, 525. 96	205, 320. 99
Rhode Island	809, 996. 93	504, 423. 07	859, 966. 07	9, 731. 81
South Carolina	809, 542. 15	508, 360. 12	860, 000. 00	260, 159. 20
South Dakota	753, 250. 00	505, 000. 00	860, 000. 00	106, 891. 92
Tennessee	810, 000. 00	510, 000. 00	860, 000. 00	327, 179. 48
Texas	810, 000. 00	507, 592. 26	860, 000. 00	653, 470. 82
Utah	775, 000. 00	509, 821. 94	860, 000. 00	45, 953. 60
Vermont	810, 000. 00	510. 000. 00	860, 000. 00	45, 813. 25
Virginia	808, 766. 58	508, 544. 94	859, 994. 27	311, 257. 45
Washington	748, 414. 70	506, 080. 11	860, 000. 00	129, 131. 28
West Virginia	809, 804. 16	506, 263. 82	859, 942. 89	235, 433. 80
Wisconsin	810, 000. 00	510, 000. 00	860, 000. 00	263, 483. 85
Wyoming	765, 000. 00	508, 850. 59	860, 000. 00	29, 572. 90
Total	38, 788, 848. 49	24, 650, 453. 56	41, 467, 187. 95	10, 489, 290. 09

ADDRESS LIST OF AGRICULTURAL EXPERIMENT STATIONS

ALABAMA.—*Auburn*, M. J. Funchess, Director.
ALASKA.—*College*, L. T. Oldroyd, Director.
ARIZONA.—*Tucson*, P. S. Burgess, Director.
ARKANSAS.—*Fayetteville*, W. R. Horlacher, Director.
CALIFORNIA.—*Berkeley*, C. B. Hutchison, Director.
COLORADO.—*Fort Collins*, H. J. Henney, Director.
CONNECTICUT.—*New Haven*, W. L. Slate, Director; *Storrs*, E. G. Woodward, Director.
DELAWARE.—*Newark*, G. L. Schuster, Director.
FLORIDA.—*Gainesville*, Wilmon Newell, Director.
GEORGIA.—*Experiment*, H. P. Stuckey, Director.
HAWAII.—*Honolulu*, J. H. Beaumont, Director.
IDAHO.—*Moscow*, E. J. Iddings, Director.
ILLINOIS.—*Urbana*, H. P. Rusk, Director.
INDIANA.—*La Fayette*, H. J. Reed, Director.
IOWA.—*Ames*, R. E. Buchanan, Director.
KANSAS.—*Manhattan*, L. E. Call, Director.
KENTUCKY.—*Lexington*, T. P. Cooper, Director.
LOUISIANA.—*University Station, Baton Rouge*, W. G. Taggart, Director.
MAINE.—*Orono*, F. Griffee, Director.
MARYLAND.—*College Park*, R. B. Corbett, Director.
MASSCAHUSETTS.—*Amherst*, F. J. Sievers, Director.
MICHIGAN.—*East Lansing*, V. R. Gardner, Director.
MINNESOTA.—*University Farm, St. Paul*, C. H. Bailey, Director.
MISSISSIPPI.—*State College*, Clarence Dorman, Director.
MISSOURI.—*Columbia*, M. F. Miller, Director.
MONTANA.—*Bozeman*, Clyde McKee, Director.
NEBRASKA.—*Lincoln*, W. W. Burr, Director.
NEVADA.—*Reno*, S. B. Doten, Director.
NEW HAMPSHIRE.—*Durham*, M. G. Eastman, Director.
NEW JERSEY.—*New Brunswick*, W. H. Martin, Director.
NEW MEXICO.—*State College*, Fabian Garcia, Director.
NEW YORK.—*Geneva* (State Station), A. J. Heinicke, Director; *Ithaca* (Cornell Station), C. E. F. Guterman, Director.
NORTH CAROLINA.—*State College Station, Raleigh*, L. D. Baver, Director.
NORTH DAKOTA.—*State College Station, Fargo*, H. L. Walster, Director.
OHIO.—*Wooster*, Edmund Secrest, Director.
OKLAHOMA.—*Stillwater*, W. L. Blizzard, Director.
OREGON.—*Corvallis*, W. A. Schoenfeld, Director.
PENNSYLVANIA.—*State College*, S. W. Fletcher, Director.
PUERTO RICO.—*Mayaguez* (Federal Station), Atherton Lee, Director; *Rio Piedras* (College Station), J. A. B. Nolla, Director.
RHODE ISLAND.—*Kingston*, M. H. Campbell, Director.
SOUTH CAROLINA.—*Clemson*, H. P. Cooper, Director.
SOUTH DAKOTA.—*Brookings*, I. B. Johnson, Director.
TENNESSEE.—*Knoxville*, C. A. Mooers, Director.
TEXAS.—*College Station*, A. B. Conner, Director.
UTAH.—*Logan*, R. H. Walker, Director.
VERMONT.—*Burlington*, J. E. Carrigan, Director.
VIRGINIA.—*Blacksburg*, A. W. Drinkard, Jr., Director.
WASHINGTON.—*Pullman*, E. C. Johnson, Director.
WEST VIRGINIA.—*Morgantown*, C. R. Orton, Director.
WISCONSIN.—*Madison*, C. L. Christensen, Director.
WYOMING.—*Laramie*, J. A. Hill, Director.

NOTE.—The full official titles, locations, and personnel of the agricultural experiment stations will be found in the list of Workers in Subjects Pertaining to Agriculture in Land-Grant Colleges and Experiment Stations, published annually by the United States Department of Agriculture.



HEADQUARTERS OF STATE AGRICULTURAL EXPERIMENT STATIONS